CANMET

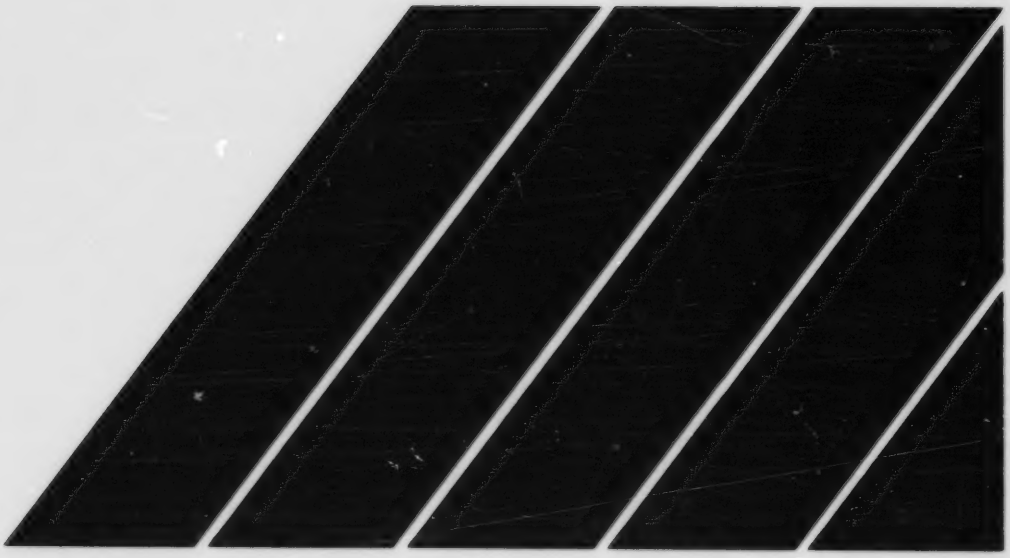
Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

Efficiency and Alternative Energy Technology Branch

Direction de la technologie de l'efficacité énergétique et des énergies de remplacement

BELL ISLAND WIND DEMONSTRATION PROJECT:
VOLUME I



Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

Canada

THE ENERGY OF OUR RESOURCES · THE POWER OF OUR IDEAS

L'ÉNERGIE DE NOS RESSOURCES · NOTRE FORCE CRÉATRICE

91-06135/

BELL ISLAND WIND DEMONSTRATION PROJECT: VOLUME I

PREPARED FOR:

Efficiency and Alternative Energy Technology Branch
Energy, Mines and Resources Canada
Ottawa, Ont.
March, 1991

PREPARED BY:

Newfoundland Light & Power Co. Ltd.
P.O. Box 8910
St. John's, Nfld.
A1B 3P6

SCIENTIFIC AUTHORITY:

Anthony Kingsley
Efficiency and Alternative Energy Technology Branch
Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ont.
K1A 0E4

108 pp

MICROMEDIA

CITATION

Newfoundland Light & Power Co. Ltd. Bell Island Wind Demonstration Project: Volume I. Efficiency and Alternative Energy Technology Branch, Energy, Mines and Resources Canada, Ottawa, Ontario. 1991 (34 pp.)

Copies of this report may be obtained through the following:

Efficiency and Alternative Energy Technology Branch
Energy, Mines and Resources Canada
580 Booth Street, 7th Floor
Ottawa, Ont.
K1A 0E4

or

Document Delivery Service
Library and Documentation Services Division
CANMET
Energy, Mines and Resources Canada
562 Booth Street
Ottawa, Ont.
K1A 0G1

DISCLAIMER

This report is distributed for informational purposes only and does not necessarily reflect the views of the Government of Canada nor constitute an endorsement of any commercial product or person. Neither Canada nor its ministers, officers, employees or agents makes any warranty in respect to this report or assumes any liability arising out of this report.

NOTE

Funding for this project was provided under the ENERDEMO Program.

© Minister of Supply & Services Canada 1991
Catalogue No. M91-7/149-1991E
ISBN. 0-662-18933-7

ABSTRACT

Newfoundland Light and Power Co. Ltd installed a grid connected 300 Kw horizontal axis wind turbine in 1988/89 to assess its operational and economic characteristics. The unit was operated for a period of 16 months producing 241,619 Kwhrs and had an overall availability of 27.5%. Numerous major problems including blade failure, controller errors and generator failure were responsible for the poor performance. It was concluded that even if the unit had operated as expected, economics could not be used to justify the installation. Reliability and costs have to be improved if wind turbines are to be considered a viable energy source.

SUMMARY

Newfoundland Light and Power Co. Ltd in conjunction with the Department of Energy, Mines and Resources installed a 300 Kw Carter Wind Systems wind turbine on Bell Island, Newfoundland in 1988/89. This project was undertaken under the Enerdemo Canada Program which was enacted to demonstrate technologies related to renewable and nonconventional energy sources.

The wind turbine was operated from April 1, 1989 to May 9, 1990. The unit produced a total of 241,619 Kwhrs, had an overall availability of 27.5 %, or excluding major repairs, 70.5% with a capacity factor of 21.3%. Numerous operating problems including blade failure, controller errors and generator failure were responsible for the poor performance.

The environmental evaluation of the installation could not be completed due to the project being discontinued. A literature study identified possible impacts as being noise, visual, electromagnetic interference and bird strikes.

The original budget for the project was $ 651,500.00. The final cost was $ 765,136.95. The numerous equipment problems encountered was the cause of the budget overrun.

Had the machine operated as expected, the project economics cannot be used to justify the installation. Reliability and costs clearly have to be drastically improved if wind turbines are to be considered a viable energy source.

RÉSUMÉ

La Newfoundland Light and Power Co. Ltd. conjointement avec le ministère de l'Énergie, des Mines et des Ressources, a installé une éolienne de 300 kW de type Carter Wind Systems dans l'île Bell, à Terre-Neuve, en 1988-1989. Le projet a été mené dans le cadre du programme ENERDEMO Canada, dont l'objet était de faire la démonstration de technologies relatives aux sources d'énergie renouvelable et non classique.

L'éolienne, qui a fonctionné du 1^{e} avril 1989 au 9 mai 1990, a produit en tout 241 619 kWh; sa disponibilité globale a été de 27,5 % de la période ou, en excluant les réparations majeures, de 70,5 %, et son facteur de charge, de 21,3%. On attribue le mauvais rendement de l'appareil à de nombreux problèmes de fonctionnement, notamment des pannes de la pale, des erreurs de régulateur et des pannes de générateur.

Il a été impossible de compléter l'évaluation environnementale de l'installation puisque le projet a été abandonné. Une étude documentaire a montré les répercussions éventuelles, à savoir le bruit, l'aspect visuel, l'interférence électromagnétique et les impacts d'oiseaux.

Le budget du projet avait été fixé à 651 500 $. Le coût final a été de 765 136,95 $. Les nombreux problèmes d'équipement sont responsables du dépassement du budget.

La simple rentabilité du projet ne permet pas de justifier l'installation, même si l'appareil avait fonctionné comme prévu. Manifestement, il faudra nettement améliorer la fiabilité et les

coûts avant que l'on puisse considérer les éoliennes comme une source d'énergie viable.

TABLE OF CONTENTS

		Page
1.	Introduction	1
2.	Project Background	2
3.	Wind Turbine Description	6
4.	Site	8
5.	Wind Site Data	9
6.	Operating Experience	11
7.	Environmental Evaluation	20
8.	Project Costs	23
9.	Information Transfer	24
10.	Conclusions	25

Appendix A - Site Location Decision Matrix

Appendix B - Carter Wind Systems Model 300

- Site Map

Appendix C - Environmental Evaluation - Final Report

Appendix D - CanWEA '89 Paper

VOLUME II

Appendix E - Status Reports

Appendix F - Wind Turbine Chronology

- Problem Reports

1. INTRODUCTION

Newfoundland Light & Power Co. Limited (Newfoundland Power) in conjunction with the Federal Department of Energy, Mines and Resources (EM&R) installed a 300 Kw wind turbine on Bell Island, Newfoundland in 1988/89. This project was undertaken under the Enerdemo Canada Program which was enacted by the Canadian government to demonstrate technologies related to renewable and nonconventional energy sources. The specific objectives of the installation were;

(i) to identify the potential for grid connected wind turbines in Newfoundland.

(ii) to monitor the operational parameters associated with wind turbine equipment and assess the performance in the Newfoundland climate.

(iii) to evaluate the project economics based on the actual power generated by the wind turbine and the actual capital and operating costs.

(iv) to evaluate the reliability of wind generation.

(v) to assess the environmental impact of a wind turbine installation.

(vi) to provide information and technology transfer to interested parties.

2. PROJECT BACKGROUND

The project originated in 1986 when Newfoundland Power made a proposal to the Canadian government under the Solar Energy Development Program. It was proposed that a study be undertaken to determine if wind turbines could be economically feasible if installed near existing hydroelectric generating sites. This submission was rejected due to the amount of funding required, but Newfoundland Power was encouraged to pursue the idea with Energy, Mines and Resources.

Over the next two years studies were performed on the feasibility of establishing a wind demonstration project in Newfoundland. The studies included the selection of an appropriate site, the selection of the most cost effective wind turbine and the determination of the external funding required to make the installation economical to the utility.

Potential sites for the demonstration were selected using the following criteria;

(i) to permit effective monitoring and maintenance, it must be close to the Company's head office.

(ii) the site must have favorable wind conditions.

Thirteen potential sites were identified from maps and site visits and a matrix was used to select the optimum location. Parameters used in the matrix were;

- wind conditions.
- site topography.
- site safety.
- icing conditions.
- foundation material availability.
- site accessibility.
- communication interference possibility.
- land availability.
- demonstration visibility.
- transmission line connection distance.
- expansion possibility.
- site security.

Based on the analysis, the Bell Island site was chosen. The decision matrix may be found in Appendix A.

The type of wind turbine to be installed was determined by issuing a questionnaire to various turbine manufacturers. This was to assess the manufacturer's interest in the project and to obtain information on the production and operating characteristics of the different machines.

Following the review of the questionnaire responses, tenders were prepared and issued for the supply, erection and commissioning

of one wind turbine. The unit size was specified to be between 250 and 500 Kw. Bids were received from four companies; Indal Technologies, Carter Wind Systems, Wincon, and Howden. The bids were evaluated with respect to cost and generation and it was determined that the most economical unit was the Carter 300 Kw machine. Carter Wind Systems estimated that their machine would produce 650,000 Kwhrs annually in an average windspeed of 6.8 m/s. The purchase price of this machine was $330,000.00 (Canadian).

Once the wind turbine was selected the total project cost was estimated. From this estimate, Newfoundland Power's financial contribution and the funding requirement from Energy, Mines and Resources were determined. The contribution of $ 215,200 by the Company was calculated by comparing the present worth of the average annual generation to the present worth of the cost to purchase, erect, test, and operate the unit. Parameters used in this analysis were:

(i) a turbine life of 20 years.
(ii) an inflation rate of 5%.
(iii) an annual operating cost of 2% of the machine's price.
(iv) a cost of capital of 12.34%.

The total project cost was estimated at $ 651,500.00. The cost breakdown was as follows;

Purchase and Erect Turbine	$ 380,000.00
Substation and Controls	$ 30,000.00

Civil Works	$ 61,000.00
Transmission Line	$ 35,000.00
Land	$ 15,000.00
Environmental Study	$ 25,000.00
Monitoring	$ 50,000.00
Engineering/Administration	$ 18,000.00
Field Supervision	$ 7,500.00
Information Transfer	$ 30,000.00
Total	$ 651,500.00

In March of 1988 the Enerdemo agreement between the two parties was signed. Work started immediately with the ordering of the Carter wind turbine on March 31, 1988.

3. WIND TURBINE DESCRIPTION.

The Carter 300 Kw unit was the first and only wind turbine of that size built by Carter Wind Systems. It is a downwind, two bladed, horizontal axis machine. The 23 metre diameter blades are fibreglass composite, fixed pitch type and drive a planetary gearbox connected to an AC induction generator. All components are mounted in a pod on top of a 50 metre tilt up tower. Power and control cables from the pod are located inside the tower. The unit controls are located at the base of the tower in a separate cabinet.

In winds below 3.6 m/s, the blades of the turbine spin freely at a speed proportional to the windspeed. At about 3.6 m/s there is enough energy to bring the blades up to synchronous speed. Once the generator has reached approximately 1800 rpm (blades 67 rpm) the controller signals the silicon controlled rectifiers (SCR's) to fire and tie the unit onto the grid. The SCR's can turn the generator on and off 120 times per second thus varying the generator's excitation voltage. This enables the generator to run at the most efficient voltage for a given load. At loads greater than 100 Kw, the excitation voltage is not varied. Even though the generator's excitation voltage is varied, the output to the grid remains constant at nominally 600 volts.

At the on-line point, the generator produces under 1 Kw of power and at approximately 16 m/s, 300 Kw is produced. Momentary peaks of up to 330 Kw can occasionally occur in high, gusty winds. As the windspeed exceeds the rated power of the unit, the

aerodynamic design of the blades cause stalling to occur which effectively limits the peak power output. No high wind shutdown is required though the controller may be programmed to deactivate the machine in winds exceeding 33 m/s in order to reduce wear on the machine components.

Abnormal conditions such as power outages are handled by a failsafe safety feature built into the blades. As the blades rotate, centrifugal forces try to force the blade to pitch or twist out of the wind. The blades are kept in place by strong electromagnets inside them. Any loss of voltage removes the power from the magnets which allow the blades to pitch to a high angle of stall. The shaft speed reduces to zero and a service brake locks the rotor in place. The blades gradually reset to the fixed pitch position and the turbine will restart once power is restored. In addition to the power failures, the controller may be programmed to trip the unit for a number of dangerous conditions.

The wind turbine tracks the wind using an active yaw drive system in low and medium winds. In higher winds, the yaw drive is disengaged as the design of the blades will allow natural tracking.

The base of the tower is hinged to allow servicing of the blade/pod system by lowering it to the ground via a ginpole and winch.

A full technical description of the wind turbine is contained in Appendix B.

4. SITE

The wind turbine is located on Bell Island, Newfoundland at Latitude 47° 37' 12.95", Longitude 52° 57' 52.50". A map indicating the location is contained in Appendix B.

The installation requirements for the Carter unit were minimal. An access road was built and the site cleared and graded. Foundations for the tower base and control cabinet and four guy anchors were poured. A small building was erected to house spare parts and communication equipment. The area around the wind turbine was fenced. A 12.5 Kv, three phase transmission line was run 1.5 Km to the site and three transformers were installed to match the unit voltage to that of the transmission line.

The wind turbine arrived on site mid November, 1988 and was installed in two days by two Carter Wind Systems workers and four Newfoundland Power employees. It is interesting to note that the only lifting device required for this process was a small Pittman crane. The transmission line was completed in early December and commissioning began mid month. Due to some faulty components, the commissioning could not be completed until early January, 1989 after which the wind turbine was placed into operation for a trial "shake-down" period. By mid March the machine was fully commissioned and it was placed into operation for the monitoring phase of the project on April 1, 1989.

5. WIND SITE DATA

.1 Wind Turbine

The wind turbine was operated from April 1, 1989 to May 9, 1991. During that period, the unit produced a total of 241,619 Kwhrs. The unit availability excluding major repairs was 70.3 % with the capacity factor being 21.3 %. The overall unit availability is estimated to be 27.5 % with the overall capacity factor 8.3 %. The Carter turbine consistently met or exceeded it's published performance curve. The reports submitted to EM&R are contained in Appendix E.

Reports were forwarded to EM&R on a monthly basis while the unit was operating. This data included windspeed versus instantaneous output and windspeed versus corrected hourly average output for the reporting period. All corrections to data were made in accordance with CSA Standard F416-M1985 and CSA Standard F417-M1986.

.2 Wind Monitoring

A wind data recorder was installed on the site during the monitoring period. The recorder was purchased from Second Wind Inc. and information to be gathered by this device included;

- peak wind speed.
- longest energy lull.

- slow, medium and fast velocity distributions.
- wind rose data.
- dinural data.
- monthly average wind speed.
- hourly average wind speeds.

This data was to be forwarded to EM&R during the periods that the wind turbine was operating. Persistent problems with the monitor lead to erroneous and inconsistent data. The device was returned to the manufacturer twice but they could not find any reason for the data loss. The result of these problems was that the information collected was too sparse to be of any use. The wind data collected by the wind turbine controller was submitted to EM&R in place of the Second Wind information. This information was average wind speed versus duration but, unfortunately, this was only collected during the period that the wind turbine was operating and thus could not be used to characterize the site.

6. OPERATING EXPERIENCE

A chronology detailing significant events during the wind demonstration project is included in Appendix E.

During the months of January, February, and March, 1989 a lot of time was spent eliminating problems associated with the startup of new equipment. Some of these problems were due to control components rated for 480 volts being used at 600 volts. This was a supplier problem as the unit was specified for use at 600 volts. A fault occurred in the electrical cable running between the unit and it's transformers. This necessitated the installation of temporary above ground cabling until weather conditions permitted replacement. The center phase transformer developed a fault in March, 1989 which caused damage to the wind turbine's surge protection and main circuit breaker. After installing another transformer and repairing the damage to the unit, a new ground fault protection scheme was implemented. On April 4, 1989 cracks were discovered at the base of the tower. It is speculated that these were caused by misalignment of the tower guy wires. On each blade rotation the bending forces transmitted to the tower were translated into torsional loads due to the misalignment. This torsion caused fatigue failure of the thin tower material at the base of the tower. The cracks were ground out and welded. Later support plates were installed between the tower pivot brackets to absorb the torsional loading.

On May 8th, 1989 a complete maintenance check was performed on the machine. At this time 86,181 kwhrs had been produced in 688 available hours. It was discovered that both blades were severely damaged and this necessitated the immediate deactivation of the unit. As a safety precaution the blades were removed.

The spar which mated Blade #99B to the blade hub was found to be splintered and delaminated on the trailing edge. This delamination was approximately 6.3 mm wide by 19 mm thick and appeared to run the entire length of the member. The support wedge in the leading edge was totally separated from the shear web and the wound glass. Cracks were found on the leading and trailing edges of the blade root. The tip of the blade had cracks which were 255 mm in length on the top skin and 150 mm long on the bottom skin. There were fractures around a plug located halfway down the length of the blade.

Blade #99A had delamination of the trailing edge of the spar and there was a possible fracture of the section. Cracks were discovered on the trailing edge of the blade root as well. Fractures were evident around a plug section approximately half way down the length of the blade and there was some impact damage about three quarters the way down the blade.

In addition to the blade problems, the rubber in the elastomeric bushings were found to be cracked. Operators of the 20 metre blade diameter in California reported that cracks were appearing in the leading edge arms. This was traced to a casting

problem and since the Bell Island unit arms were manufactured using the same method, cracks were expected to appear in those as well.

The blade failed due to a manufacturer's design error. To minimize the bending of the blade during operation, thrust and centrifugal forces are balanced by angling the blade mounting plates on the hub. This angle or precone was set at 4 degrees. This precone was insufficient resulting in excessive blade bending and eventual failure of the structural components of the blades. Carter Wind Systems had gone out of business by this time and, as a result, there was no longer a warranty in effect. Redesigned stronger blades, a blade hub with a precone of 10 degrees and other necessary replacements were ordered from International Wind Systems, a new company set up by one of the principals of Carter Wind Systems. The new components were manufactured during the summer of 1989 and installed during the week of August 21st, 1989.

The wind turbine operated during the period of August 23rd, 1989 to October 11th, 1989 with a minimum of problems. The main difficulty was found to be communications errors. Operating data was retrieved and the unit checked from Head Office via computer program and modem. The telephone lines on Bell Island were in poor condition and often the controller would receive noise which would shut down the machine. These shutdowns would be undetected until the next interrogation. The controller software was modified to eliminate this problem. On one instance, the wind turbine tripped due to the operation of the vibration switch mounted on the generator. The manufacturer revealed that this switch was set at

trip level of 0.5 g. It was felt that this setting was too conservative for a wind turbine application so it was increased to 1 g. The unit had to be shut down to replace the oil in the gearbox. Tests showed that the original oil had a high level of silicon and may have had some oxidation present. The oil degradation was probably due to overheating caused by poor air flow or due to a localized hot spot in the gearbox.

A maintenance inspection performed on October 11th revealed cracks on the trailing edges of the blades. The unit had produced a total of 58,403 Kwhrs with the new blades. Blade #81A had cracks located 5391 mm down it's length which ran perpendicular to the edge on the top and bottom skins for lengths of 51 mm each. Blade #73B exhibited the same type of cracking located 5398 mm down the length of the blade and running lengths of 16 mm on the top and bottom skins. The wind turbine was shut down on October 14th to prevent further propagation of the cracks. The blades were removed and transported to a warehouse for repair. The actual repair was delayed for several weeks due to problems encountered in obtaining the epoxy hardener.

During the weeks of December 3rd and 10th Jay Carter Jr. of International Wind Systems was on site to supervise the blade trailing edge repair. The repair consisted of reinforcing the trailing edges with fibreglass material. Once the blades were reinstalled the unit was tested and numerous additional operating problems encountered. These were traced to the controller and it had to be returned to the manufacturer, Active Controls, for repair.

One of the problems discovered was that the controller was not sensing unit speed correctly. This resulted in undetected very high overspeeds when the unit tripped. High overspeeds cause the blades to go into "edgewise flutter" or uncontrollable lengthwise twisting. This type of loading is destructive as the blades are not designed to have high torsional strengths. This has been suggested as the most likely cause of the trailing edge cracks as their locations were probably the weakest points on the blades.

During the week of January 22nd, 1990 Jay Carter Jr. and Toby Landes of Active Controls were on site for repairs to the control and electrical systems. All outstanding problems were resolved and the wind turbine was put back into operation on January 26th, 1990.

Many of the problems encountered with the machine during the next operating period were due to high winds. Blade pitchups caused a large amount of downtime. High gusty winds would overcome the holding power of the electromagnets which keep the blades from pitching up. If two pitchups occurred in one hour the wind turbine controller was programmed to lock out the unit until 1900 hrs the next day when a special reset was performed. The holding power of the magnets was increased by installing capacitors across their power supply. Even with this, the pitchups continued to occur in extremely high winds. To limit downtime, the controller software was modified to reset six hours after the second blade pitchup.

Another problem due to high winds was overproduction. On February 8th, 1990 the pitch of the blades had to be changed from 0^{o}

to 1^{o} to eliminate the overproduction and associated unit trips such as generator overtemperature and overcurrent. Overheating of the gearbox was a possibility. Prior to the pitch change, the high quarter hour production was 334 Kw at a quarter hour average windspeed of 82 Km/h. Following the 1^{o} change in pitch, the high quarter hour output dropped to 304 Kw at a quarter hour average windspeed of 67 Km/h. Though the windspeeds were different, a review of the windspeed versus instantaneous output curve revealed that the production curve for the new blade setting flattened out at approximately 74 km/h. A hole was cut in the front of the nacelle to increase the cooling air flow across the generator and gearbox.

Other operating difficulties during this period included excess yaw and weak clutch trips.

On February 21^{st}, the unit would not restart following a trip and the machine was disabled pending a site visit. The inspection revealed that 3 of 4 tapered bolts holding the B blade to the hub had come off. The machine had produced 123,081 Kwhrs with the new blades for a total of 209,262 Kwhrs. It is suspected that the bolts did not fit properly thus allowing the nuts to back off during operation. The wind turbine was shut down pending the arrival of modified bolts.

On April 6th, repairs were carried out. The B blade was inspected for damage. Other than part of the circumferential winding on the root being slightly damaged, the blade was found to be in good condition. The bolts holding both blades to the hub were replaced with new longer ones and new locknuts were installed. During this work it was discovered that the B blade electromagnet had failed. As mentioned earlier, in an effort to reduce blade pitchups, the voltage to the magnets had been increased. The resulting current draw was on the limit of the rating of the wire used to manufacture the coil. It is felt that the magnet failure was due to the subsequent overloading of the wire. The spare electromagnet was installed and the voltage reduced. On reactivation, the blades once again began to pitch up in high winds.

A possible modification to the magnets to increase the holding power was discussed with International Wind Systems. The only change that could be made was to fabricate the body out of pure iron instead of the hot rolled steel currently used. This had been done on the Carter 200 Kw machines and holding power was increased by approximately 15 %.

International Wind Systems also informed Newfoundland Power that there was a potential problem with the yaw clutch. The vendor who manufactured them did not heat treat some of the shafts used. This will cause the clutches to fail prematurely.

On May 7th, 1990 problems were encountered with communicating with the wind turbine. The controller refused to respond to any commands for long periods of time. When the unit did transmit information, it was in random order. It was noted that the wind anemometer was not working and that some of the controller settings had changed. On May 8th a site visit was made to investigate the problems. There were no particular anomalies noted except that the back up batteries to the controller had low voltage. It was thought that the low voltage may have lead to the controller problems as there had been power outages during the previous week. The anemometer was found to be nonoperational but as there had been heavy icing during the previous week it was suspected that some damage had occurred. The controller was checked and found to be operating correctly. The wind turbine was put on line and, at approximately 80 Kw, a puff of black smoke was observed to come from the generator cooling vent. The unit was shut down immediately.

On May 9th the generator problems were investigated. It was noted that there was burned wire insulation at the base of the tower. The machine was lowered and the inside of the tower inspected. The strobe power cable insulation was melted off almost it's entire length and it was found to be faulted where it turned to attach to the strobe. The anemometer cable was burned off. The generator power cable was disconnected at the control cabinet and at the generator, meggared at 1000 Volts and found to be in satisfactory condition. The generator was checked and found faulted to ground. It was discovered that the spare controller was not working properly and that it's keypad was defective. The blades

were inspected and it was noted that both were beginning to show signs of stress.

It was estimated that it would cost $ 22,000 to repair the generator, $ 450 to fix the controller, $ 3,300 for new electromagnets and $ 250 for a new yaw clutch. As a significant amount of money had been spent by Newfoundland Power in maintaining and operating the unit, EM&R was requested to provide funding for the latest repair. After some discussion, it was mutually decided in October, 1989 to deactivate the machine.

Detailed reports on the various operating problems and repairs may be found in Appendix F.

7. ENVIRONMENTAL EVALUATION

On October 17th, 1989 tenders were issued for the performance of an environmental study on the wind turbine installation. Three bids were received and, following review by Newfoundland Power and Energy, Mines and Resources, the project was awarded to Ledrew, Fudge and Associates of St. John's, Newfoundland at a cost of $ 19,712.00. The environmental evaluation was to have addressed several aspects of the installation including;

- acceptance by the general population.
- noise levels.
- effect on wildlife and domestic animals.
- communication interference.
- effect on tourism and visitors to the island.
- safety of surrounding properties and individuals.
- potential health hazards.
- economic benefits/drawbacks.

The Ledrew, Fudge and Associates final report may be found in Appendix C.

The evaluation could not be finished due to the generator failure and subsequent cancellation of the project. The environmental study essentially became a literature review to identify potential environmental and social benefits and problems.

The major items addressed by Ledrew, Fudge and Associates were;

.1 Socio/Economic

- Employment - though one wind turbine cannot generate significant employment, it was estimated that 6 to 10 jobs would likely be created for each 10 Mw or 100 machines installed.

- Tourism - there would be a significant tourism element to the construction of a large wind turbine or wind farm as long as it was placed in a location that was readily accessible to the public.

- Health and Safety - this is a concern from three conditions; structural failure, electrocution and falling ice.

- Economy - the effect of wind turbine machinery on local economies was found to be not well documented.

.2 Noise

Two possible sources of noise were identified; aerodynamic from the blades and generator noise. Modern wind turbines produce very little noise but it was found that researchers are continuing to address public concerns.

.3 Aesthetics/Visual

One of the greatest environmental impacts is perceived to be visual. It was stated that the public perception of wind turbines could be a major hurdle facing the industry.

.4 Electromagnetic Interference

Rotating blades may distort the video portion of a television signal and disrupt reception in the vicinity of the machine. Audio portions are reportedly not effected. There is no significant interference reported in AM/FM or aircraft navigation systems.

.5 Land Use

Occupation of land is not considered to be a major effect as the land below the wind turbines may still be used for other purposes such as farming.

.6 Natural Environment

The main concern is that of bird strikes. It is only significant if the wind site is close to nesting areas or migratory routes.

8. PROJECT COSTS

An increase in EM&R funding of $ 113,636.95 was required to cover the cost of replacement blades purchased in 1989 and some additional unit repairs. The total actual costs incurred at project completion were as follows:

Purchase and Erect Turbine	$ 470,006.25
Substation and Controls	$ 39,760.20
Civil Works	$ 54,576.52
Transmission Line	$ 41,642.02
Land	$ 15,622.11
Environmental Study	$ 14,853.38
Monitoring	$ 50,000.00
Engineering/Administration	$ 42,421.47
Field Supervision	$ 33,241.04
Information Transfer	$ 3,013.96
Total	$ 765,136.95

Actual funding received from EM&R was $ 458,619.20 leaving Newfoundland Power's contribution at $ 306,517.75.

9. INFORMATION TRANSFER

The Canadian Wind Energy '89 conference held in Charlottetown, Prince Edward Island on September 18 - 21, 1989 was attended. The paper " Bell Island Wind Demonstration Project: Case Study" was presented at this time. This paper is included in Appendix F.

10. CONCLUSIONS

.1 A Carter Wind Systems 300 Kw wind turbine was installed on Bell Island, Newfoundland in 1988/89 by Newfoundland Power under an Enerdemo agreement with Energy, Mines and Resources.

.2 The overall wind turbine availability was 27.5% with the capacity factor being 8.3%. Factoring out major repairs raises these figures to 70.3% and 21.3% respectively.

.3 During operation, the Carter 300 Kw unit consistently met or exceeded the published performance curve.

.4 Insufficient data was collected to characterize the wind regime on Bell Island because of problems with the data logger and low machine operation.

.5 Many difficulties were encountered during the operation of the unit. The major ones included blade failure, controller errors and failures, electrical problems and generator failure.

.6 The wind turbine produced a total of 241,619 Kwhrs during the 16 months at an availability of 27.5%. The original estimate of annual production was 650,000 Kwhrs and a simple projection, based on 95% availability, suggests that this would have been reached.

.7 The original project cost estimate was $ 651,500.00 with Newfoundland Power contributing $ 215,200.00 based on breakeven costs.

.8 The total final project cost was $ 765,136.95.

.9 The final cost exceeded the budget by $ 113,636.95. Newfoundland Power's contribution exceeded it's intended amount by $ 90,317.75. The reason for the cost overrun was the numerous equipment problems encountered.

.10 The environmental evaluation could not be completed due to the cancellation of the project. The literature review which replaced the evaluation identified the possible impacts as being noise, visual, electromagnetic interference and bird strikes.

.11 It was decided by EM&R and Newfoundland Power to discontinue the monitoring phase of the project following failure of the generator.

.12 Had the machine operated as expected, the project economics cannot be used to justify the installation. It is felt that such unit installations should still be considered as research and development.

.13 Reliability and cost clearly have to be drastically improved if wind turbines are to be considered a viable energy technology.

APPENDIX A

Site Location Decision Matrix

WIND FARM SITE SELECTION

General Basis for Site Selection

1. The selected site will be limited to the St. John's area for ease of monitoring.

2. Possible sites were selected from topographic maps and preliminary site inspections were performed. These sites were selected ensuring that the topography provided favorable wind conditions.

3. A selection matrix using 12 criteria was formulated and each site evaluated with respect to the criteria.

EVALUATION MATRIX

WIND FARM SITE SELECTION

Criteria	Wind Field	Topography	Safety	Icing	Foundation Material	Access	Neg. Comm. Interference	Land Availability	Demo. Availability	Connection Distance	Expandability	Security	TOTAL
Maximum Weight	Yes/No	30	Yes/No	10	10	Yes/No 25	Yes/No	Yes/No 10	5	30	5	5	\\\\\
Location	\\\\\\\	\\\\\\\\\\	\\\\\\	\\\\\	\\\\\\\\\\	\\\\\\\\\	\\\\\\\\\\\	\\\\\\\\\\\	\\\\\\\\\\\	\\\\\\\\\	\\\\\\\\\\\	\\\\\\\\	\\\\\
Petty Hr-Southside	Yes	20	Yes	0	10	Yes 5	Yes	Yes 10	5	25	5	5	85
Bell Island	Yes	25	Yes	0	10	Yes 20	Yes	Yes 10	4	25	5	2	101
Red Cliff	Yes	15	Yes	0	10	Yes 25	Yes	Yes 10	0	20	1	3	84
Talc Mine	Yes	10	Yes	0	10	Yes 5	Yes	Yes 5	2	30	2	5	69
Fort Motel Ridge	Yes	30	Yes	5	10	Yes 25	No	No	4	30	2	5	N/A
Torbayman's Pond	Yes	20	Yes	5	10	Yes 25	No	No	4	20	0	5	N/A
Topsail Bluff	Yes	10	Yes	0	10	Yes 20	Yes	Yes 5	4	25	5	4	83
Hawkes Hill	Yes	30	Yes	5	10	Yes 5	Yes	Yes 10	3	0	5	3	72
Bay Bulls - Big Pd	Yes	20	Yes	5	10	Yes 10	Yes	Yes 10	3	20	5	4	87
Kenmount Hill	Yes	25	Yes	5	5	Yes 10	No	Yes 5	5	30	5	3	N/A
White Hills	Yes	20	Yes	5	10	Yes 20	Yes	No	5	30	4	4	N/A
Witless Bay Line	Yes	20	Yes	10	5	Yes 15	Yes	Yes 10	3	15	5	4	87
Goulds Substation	Yes	25	Yes	5	10	Yes 15	Yes	Yes 10	4	15	5	5	94

CRITERIA DESCRIPTION

1. Windfield - This will be given a "Yes" or "No" rating. A "Yes" designation for any site will indicate the average annual wind speed is sufficient to power a wind turbine. A "No" designation will disqualify the site.

2. Topography

   (a) The site is exposed to the wind from all directions and there are no terrain features within 10 Km which would create unacceptable wind patterns such as turbulence and wind shear - 30 Points.

   (b) The site is exposed to wind from all directions but there are higher points of land within 10 Km of the site - 20 Points.

   (c) The site is exposed to prevailing wind but blocked by higher feature in another direction - 10 Points.

   (d) The site is located in a potential area of high turbulence - 0 Points.

3. Safety - This will be given a "Yes" or "No" rating. A "Yes" designation for any site will indicate that there are no inhabitants within 300 Metres of the site or other identifiable safety hazards. A "No" designation will disqualify the site.

4. Icing - In areas that experience freezing rain and drizzle, ice accumulation on blades can reduce efficiency or shut down the wind turbine completely. Noncoastal sites will be given a 10 Point score and costal sites will be given a 0 Point score.

5. Foundation Material
   (a) Exposed or thinly covered bedrock - 10 Points.
   (b) Till or tree covered areas - 5 Points.
   (d) Bog - 0 Points.

6. Access - This will be given a "Yes" or "No" rating as well as a points score. A "Yes" designation for any site will indicate that it is able to be made accessible. The "Yes" designation will require a further assignment of points as shown below. A "No" designation will disqualify the site.
   (a) Site completely accessible by road/boat - 25 Points.
   (b) Site accessible with upgrading of road - 20 Points.
   (c) Site requires construction of access road less than 1 Km - 15 Points.
   (d) Site requires construction of access road more than 1 Km - 10 Points.
   (e) Access road construction possible but very difficult - 5 Points.

7. Negligible Communication Interference - This will be given a "Yes" or "No" rating. A "Yes" designation for any site will indicate communication interference is negligible. A "No" designation will disqualify site.

8. Land Availability - This will be given a "Yes" or "No" rating. A "Yes" designation will indicated that the land is available for use as a wind farm site. The "Yes" designation will require a further assignment of points as listed below. A "No" designation will disqualify the site.

   (a) The site is on crown land which is readily available for lease or purchase at a minimum cost - 10 Points.

   (b) The site is on restricted government property which would be difficult to obtain or on privately owned land which involves purchase negotiation - 5 Points.

9. Demonstration Visibility - If the wind farm is located at a site which is visible to the public, awareness of NP's work in this field will be enhanced. Five (5) Points will be awarded for visibility.

10. Connection distance from three phase line.

(a) 0 - 0.5 Km	30 Points.
(b) 0.5 - 1.0 Km	25 Points.
(c) 1.0 Km - 1.5 Km	20 Points.
(d) 1.5 - 2.0 Km	15 Points.
(e) 2.0 - 2.5 Km	10 Points.
(f) 2.5 - 3.0 Km	5 Points.
(g) > 3.0 Km	0 Points.

11. Expandability - Five (5) points will be allotted to any site which has unlimited space for expansion (50 units or more). Three (3) points will be allotted to any site with expansion capability for 10 to 50 units.

12. Security - Five (5) points will be allotted to any site requiring little or no security provisions. Zero (0) points will be allotted to sites with security problems.

FINAL SELECTION OF WIND FARM SITE

The evaluation matrix for wind farm sites evaluated 13 potential wind farm sites on a point system using 12 major criteria. This evaluation produced two sites with marked advantages over other sites. These sites were Bell Island with 101 points and Goulds Substation with 94 points.

A further economic analysis of these two sites is shown below. Items such as wind turbine purchase costs, transportation costs of the turbine, installation costs, engineering, etc. were considered to be equivalent at both sites and were therefore not included in the analysis. The only costs which are substantially different are transmission lines and access roads. These are outlined below:

Bell Island Site

1. Erect 3 Ph. line of 700 M on existing poles:	$20,000.00
2. Erect 3 Ph. line of 250 M including new poles:	$15,000.00
3. Build 250 M Of access road:	$15,000.00
Total:	$50,000.00

Goulds Substation Site

1. Erect 3 Ph. line of 750 M on existing poles:	$21,000.00
2. Erect 3 Ph. line of 850 M including new poles:	$45,000.00
3. Build 700 M Of access road:	$40,000.00
Total:	$106,000.00

On the basis of the analysis, Bell Island was chosen.

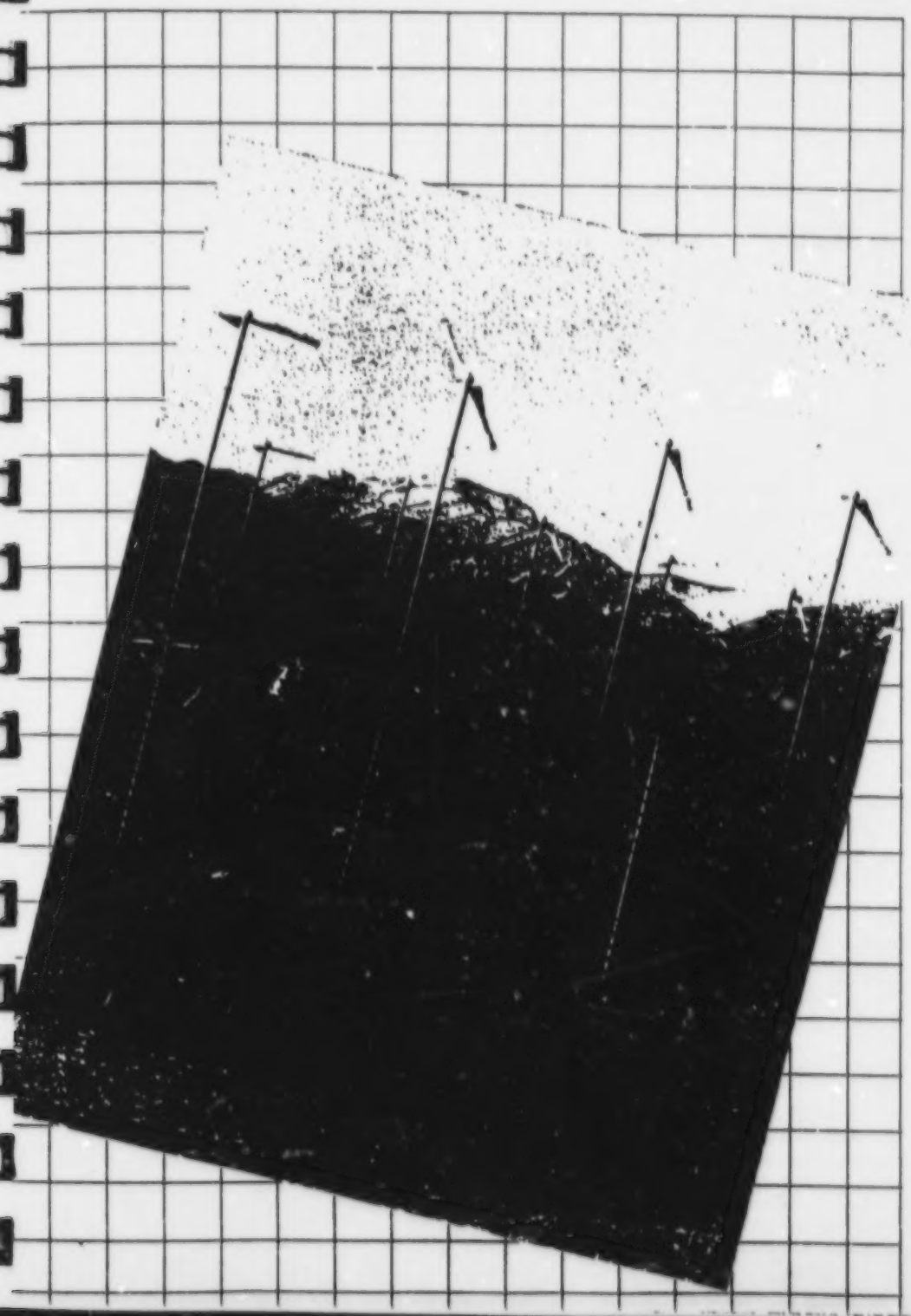
APPENDIX B

Carter Wind Systems Model 300

Site Map

Midsized
Wind Energy Converter
WEC-23, Model 200/300

CARTER WIND SYSTEMS, INC.



WEC-23 Carter Wind Systems

WEC-23 (System Carter) is a modern wind power conversion system of advanced design, fully equipped for turnkey utilization of wind energy.
For several years machines of this type have successfully performed with grid operation. At the end of 1987 more than 50 units were on line.

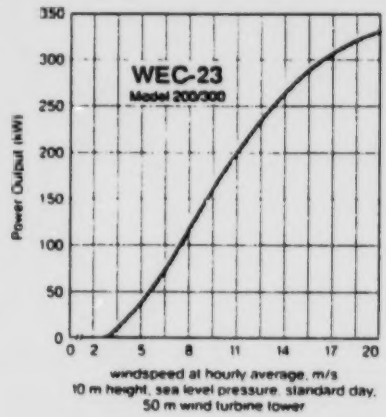
Applications

- Grid parallel operation

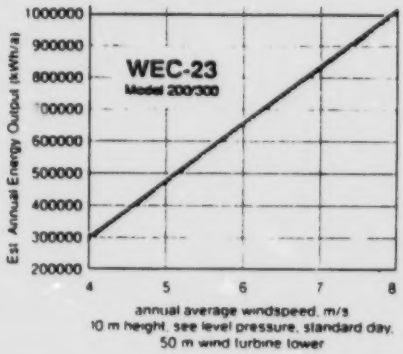
Windfarms or isolated installations, for public, industrial or private electricity users such as:

Lighting
Irrigation
Food processing
Water treatment
Cooling and heating

Power Curve



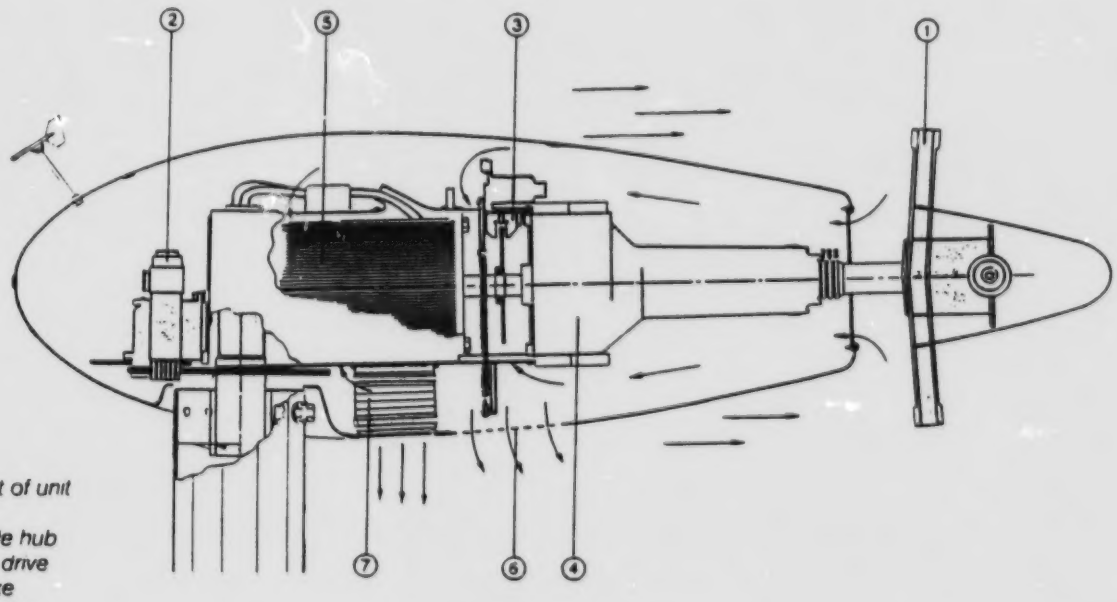
Annual Energy Output (AEO)



Particular System Advantages:

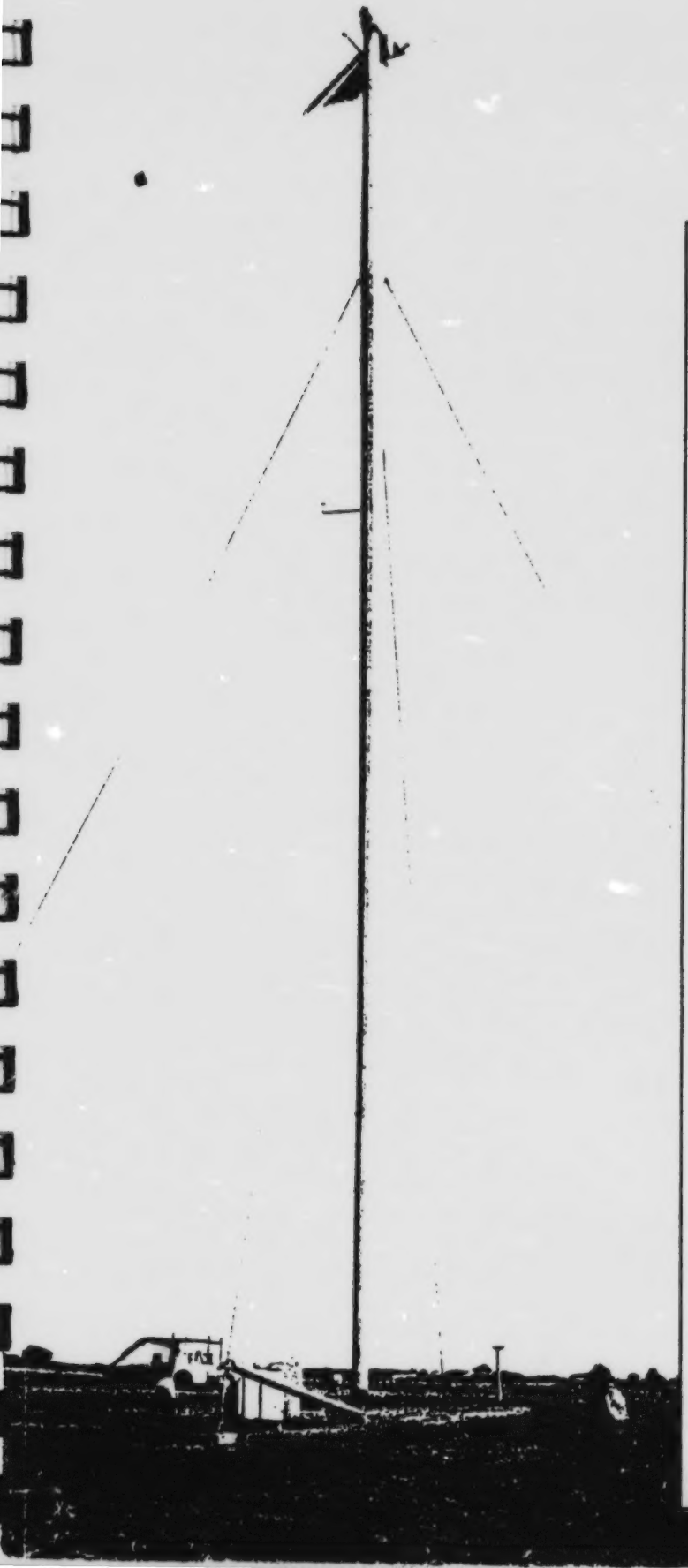
- Fully automatic operation.
- Mature safety concept.
- Compact design for low weight/power ratio.
- Tilt-up tower for ease of maintenance.
- Extreme high tower for optimized wind utilisation.
- Proven design by more than 50 units in operation.

Nacelle



Layout of unit

1 Blade hub
2 Yaw drive
3 Brake
4 Gearbox
5 Generator
6 Fiberglass nacelle
7 Ventilation



Technical Data: WEC-23 (Model 200/300)

Rotor

Type:	horizontal axis/downwind
Number of blades:	2
Area:	410 m^2
Diameter:	23 m
Speed:	67 rpm
Type of hub:	teetering hub
Tilt angle:	2.3°
Pre-cone:	4°

Blades

Material:	fiberglass composite
Blade design:	non-linear twist, taper NASA-LS airfoils
Blade pitch:	fixed

Transmission

Type:	two stage planetary
Ratio at (50 Hz):	1:22.6
Ratio at (60 Hz):	1:27.2

Generator

Type:	Induction-AC
Rated power:	300 kW
Voltage:	380 V, 50 Hz 480 V, 60 Hz
Speed:	1522 rpm, 50 Hz 1827 rpm, 60 Hz

Performance

Power:	200 kW
at windspeed:	11 m/s
Max. power:	300 kW
at windspeed:	16 m/s
Cut-in windspeed:	4 m/s
Cut-out windspeed (adjustable):	33 m/s
Guarantee max. windspeed: (all speeds measured at 10 m height)	45 m/s

Control system

Type:	aerodynamic stall controlled
Overspeed:	deep stall by twisting the spar

Yaw drive

Type:	active up to 80 kW; free yaw (dampened) above 80 kW, down to 40 kW

Tower

Type:	tubular/tilt-up
Number of guy wires:	4
Height:	50 m
Foundation:	40 m^3 concrete

Shell

Material:	fiberglass composite
Size (L x W x H):	(3.3 x 1.1 x 1.3 m)

Weights

Blades + hub:	873 kg
Tower:	7.830 kg
Nacelle:	2.147 kg
Miscellaneous: (control box, guy wires etc.)	1.250 kg
Total weight:	12.100 kg

Safety devices

- **Manual shut-off.**
- **Electronic and mechanical overspeed shutdown.**
- **Deep stall braking independant of power supply.**
- **Emergency braking and parking by means of an integrated spring-loaded disk brake.**

Carter Wind Systems
WEC-23, Model 200/300
Wind Energy Converter

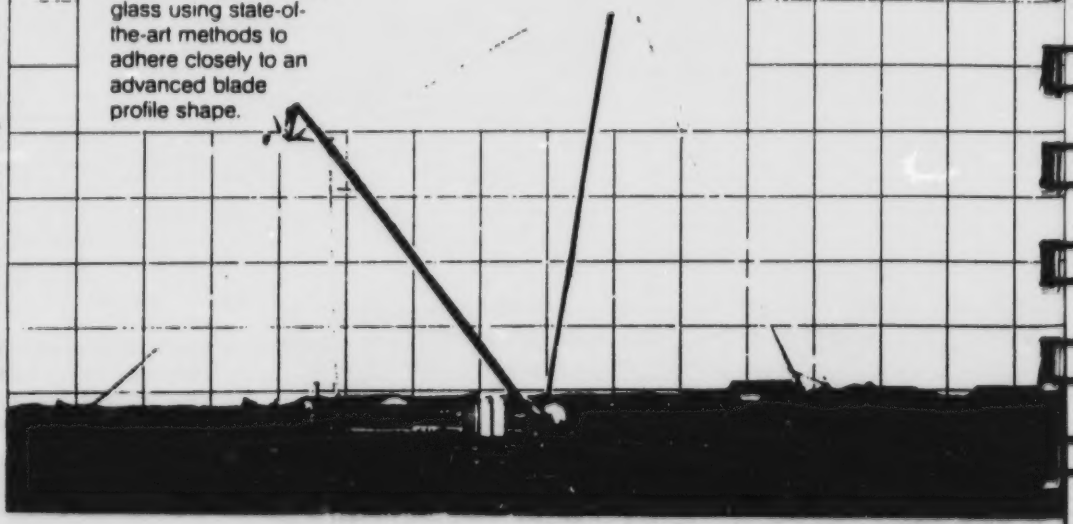
Carter Wind Systems, Inc.
FM 369, Burkburnett, Texas

Factory: 817/569-2238
FAX: 817/569-2631
Palm Springs:
619/251-1845
Tehachapi:
805/824-9141

The WEC-23 was designed by Carter Wind Systems Inc.-USA, and has been under development for the past five years.
The following distinguishing design characteristics of the WEC-23 are to be noted:

- While most turbines on the market have towers no higher than 25 m, the WEC-23 uses a 50 m guyed pole tower which allows the turbine to capture higher velocity winds at lower turbulence.
- The tower is raised and lowered via a ginpole and a winch to facilitate quick repair and maintenance safely at ground level. The use of guy wires allows the tower to be light, yet strong.
- The weight of the machinery on top of the tower is lower than for most wind turbines of comparable size because it does not use a heavy bedplate, but does incorporate a planetary gearbox which also serves to support the rotor bearings, brake module and generator.
- The rotor system has two blades made from fiberglass using state-of-the-art methods to adhere closely to an advanced blade profile shape.
- Additionally, the WEC-23 rotor system employs a centrifugally activated full-span blade pitch to prevent rotor overspeed conditions. This system uses an I-beam internal to the blade profile which flexes torsionally to accommodate blade pitch without introducing moving parts.
- The active/passive yaw drive system eliminates off-wind direction operation and potentially catastrophic upwind starts while providing necessary damping in high winds.
- A mechanical brake is adding a measure of redundancy to the system.
- The electrical grid interconnect system is state of the art providing a soft mechanical and electrical transient-free tie into a utility system.

The unit can be raised by using a winch or a truck via pulley block and ginpole. Once the tower is initially raised after first assembly, the guy cables are adjusted only once for vertical tower position and proper tension.



MAN Technologie GmbH
Dept. EV
Postfach 50 04 26
D-8000 München 50
Phone: (089) 14 80-1
Telex: 5 23 211-21 ma d
Telefax: (089) 150 7168

Authorised Reseller

In the interest of continued improvement, specifications may be changed without notice. In each case only the technical data of the scope of delivery and service to be agreed upon are binding.

BELL ISLAND WIND DEMONSTRATION PROJECT LOCATION

APPENDIX C

Environmental Evaluation - Final Report

LeDrew, Fudge
and Associates Limited

FINAL REPORT
BELL ISLAND WIND ENERGY
DEMONSTRATION PROJECT

PREPARED FOR:

NEWFOUNDLAND LIGHT AND POWER CO. LIMITED
P.O. BOX 8910, STATION A
55 KENMOUNT ROAD
ST.JOHN'S NEWFOUNDLAND
A1B 3P6

PREPARED BY:

LEDREW FUDGE AND ASSOCIATES LIMITED
607 TORBAY ROAD
P.O. BOX 9370, STATION B
ST. JOHN'S, NEWFOUNDLAND
A1A 2Y3

L-284

for Bevin R. LeDrew, President

D. Robbins, Project Manager

JANUARY 16, 1991

LIST OF FIGURES

FOLLOWING PAGE

Figure 2.1 Site Location Map 4

LIST OF TABLES

		FOLLOWING PAGE
Table 3.1	Vegetation Found in Maritime Barrens Ecoregion	6
Table 3.2	List of Birds Occurring Within the Study Area	7
Table 3.3	Classification of Rural Land, Bell Island 1975	11
Table B1	Computed Values of Ice Accumulation (CM) on Various Surfaces for St. John's (Caine and Skeates, 1974)	B-2
Table B2	Calculated Weights of Ice on System Components	B-3

1.0 INTRODUCTION

Newfoundland Light and Power Co. Limited in conjunction with the Federal Department of Energy, Mines and Resources have installed a 300 kw wind turbine on Bell Island, Newfoundland. This project was undertaken under the Enerdemo Canada Program which was created to demonstrate technologies related to renewable and non-conventional sources of energy. The objectives of this project are:

(i) to identify the potential for grid connected wind turbines in Newfoundland;

(ii) to monitor the operational parameters associated with the equipment and assess its performance in the Newfoundland climate;

(iii) to evaluate the project economics based on actual power generated by the wind turbine and the actual capital and operating costs of it;

(iv) to evaluate the reliability of wind generation;

(v) to assess the environmental impact of a wind turbine installation

(vi) to provide information and technology transfer to interested parties (Hunter 1989).

In January 1990, Newfoundland Light and Power Co. Limited (NL&P) contracted LeDrew, Fudge and Associates to conduct a socio/economic and environmental impact assessment of the Bell Island Wind Demonstration project. As of April, 1990 the second interim report on the environmental evaluation of the project had been submitted. During May, 1990 the project was put on hold by the proponent due to equipment malfunction on-site. No more additional work was done on the

environmental evaluation until a decision regarding the status of the project had been reached.

On November 16, 1990 LeDrew, Fudge and Associates Limited (LFA) were informed that Newfoundland Power (formerly Newfoundland Light and Power Ltd.) and Energy, Mines and Resources had decided to cancel further operation of the Bell Island Wind Turbine. A decision was made at this time for LFA to provide an updated final report based on the second interim report.

The report that follows is no longer an impact assessment, as the primary information which was to be completed under the original contract including a public information survey and the field wildlife survey have not been completed due to project cancellation. Instead this report will focus on the literature reviewed on other wind energy systems to provide information on possible impacts and mitigative measures which could be taken.

The impacts from wind energy conversion systems (WECS) on the natural and socio-economic environment will be discussed, as well as a brief discussion of the effects from noise and the possibility of interference with communication signals. Given the cancellation of the project before any primary information was collected this report is limited to information acquired from a literature review and certain sections of the report are incomplete.

2.0 PROJECT DESCRIPTION

2.1 PROPONENT

The proponent for this study is Newfoundland Light and Power Company Ltd. who has been commissioned by Energy Mines and Resources to produce a report

discussing the environmental impacts of the single wind turbine on Bell Island and also to project the possible impacts of a wind farm in this area.

2.2 PROJECT RATIONALE

Energy, Mines and Resources are interested in the development of alternative energy sources and wants to demonstrate the feasibility of wind farms in Newfoundland. Given the expense of other energy sources, the exposure to wind, and the undeveloped nature of much of Newfoundland, the Island would appear to be the ideal location for testing the potential of wind energy.

Bell Island was chosen from a number of other site locations for a number of reasons: the topography and wind conditions were determined to be suitable, and the site was also determined to be close enough to the Company's Head Office in St. John's to permit effective monitoring and maintenance. Other conditions which had to be considered were:

- site safety;
- icing conditions;
- availability of foundation material;
- site accessibility;
- possibility for communication interference;
- land availability;
- demonstration visibility;
- connection distance to transmission lines;
- possibility for expansion; and
- site security;

2.3 PROJECT DESCRIPTION

2.3.1 Location

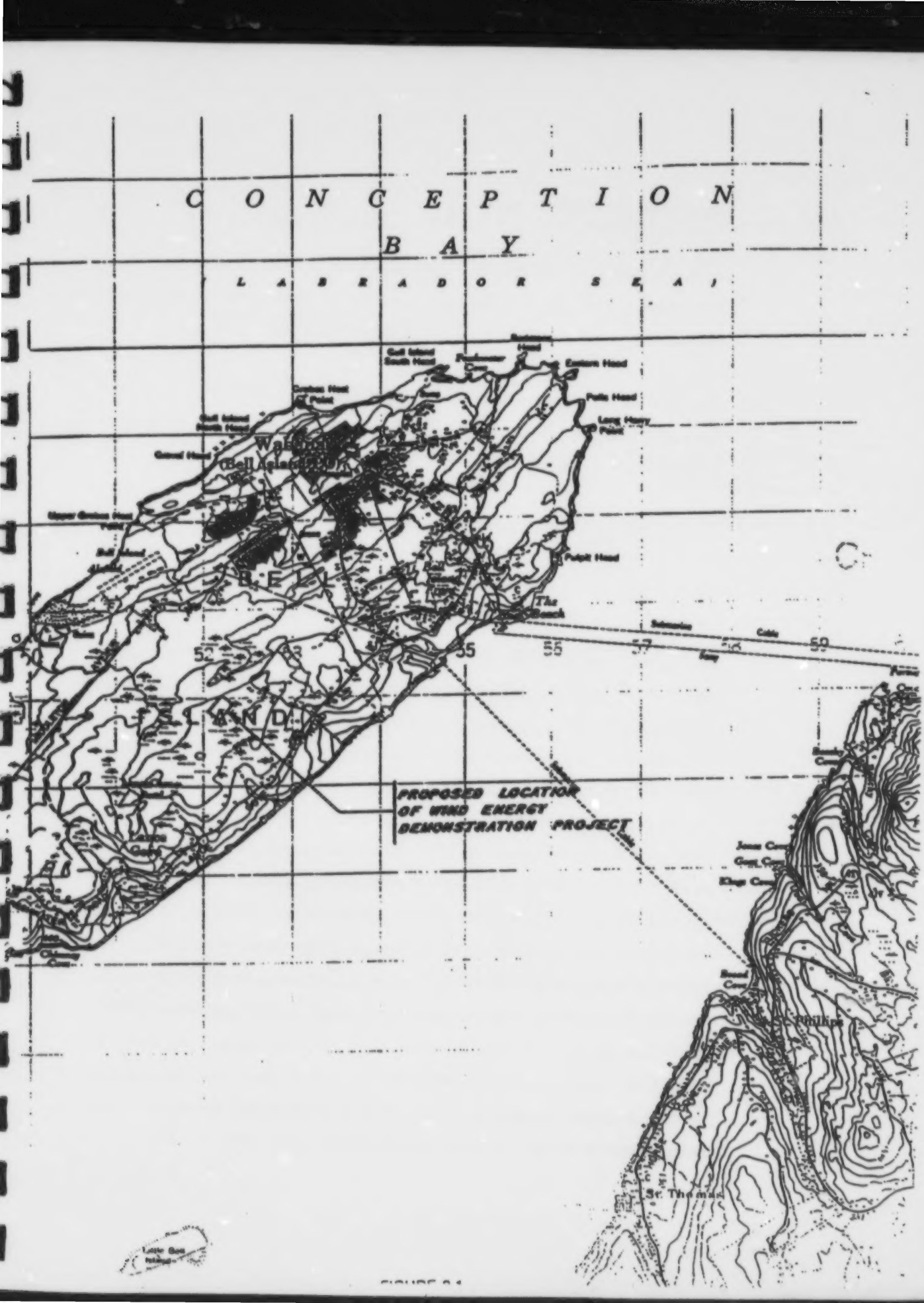
The wind turbine demonstration site is located in the area of Cummings Lane, as shown in Figure 2.1.

2.3.2 Physical Features

The wind turbine demonstration site consists of one WEC-23 (model 200/300) wind turbine made in 1988 by Carter Wind Systems Inc. of Burkburnett, Texas. The on-site equipment includes:

- a horizontal axis, downwind rotor with two fixed fibreglass blades;
- a 50m high tubular, tilt-up type tower with four guy wires;
- a generator; and
- a control system.

The installation requirements for this unit were minimal. An access road was built and the site cleared and graded. Foundations were poured for the tower base, control cabinet, and four guy anchors. A small building was erected to house spare parts and communication equipment. The area around the wind turbine was fenced. A 12.5 kV, three phase transmission line was run 1.5 km to the site and three transformers were installed to match the unit voltage to that of the transmission line.


C O N C E P T I O N
B A Y
L A B R A D O R S E A
PROPOSED LOCATION
OF WIND ENERGY
DEMONSTRATION PROJECT
Phillips
St. Thomas

2.3.3 Operation and Maintenance

Although there is a Newfoundland Light and Power representative on Bell Island who keeps a visual check on the unit the station has been monitored principally via computer from the St. John's Newfoundland Light and Power office.

Plans are for the structure to remain in place and operational for as long as is practically possible. However, the actual monitoring period began on April 1, 1989 and ends on March 31, 1991.

3.0 BASELINE ENVIRONMENTAL STUDY

3.1 STUDY AREA

Bell Island, Conception Bay, is approximately 9.5 km long by 3 km wide and 34 square km in area. The largest of three islands clustered on the east side of the Bay, its eastern side is separated from the mainland of Newfoundland by a 5 km wide stretch of water known as the Tickle. The island is composed of Ordovician sandstone and shale over Cambrian formations. Dispersed throughout the island are deposits of rich iron ore. Bell Rock, which gave the island its name, is located off the northwestern end of the island and is separated from it by a gap of several metres. There is one main road on the Island, as well as a Ferry terminal and associated fuel storage area. Freshwater on the Island is supplied from eleven wells at various locations throughout the town. The existing water system covers only part of the town however, so many town people rely on private wells, some of which have been condemned by the Department of Health. Aside from the lack of municipal water supply in some areas of the town, the major problems of the existing system are the lack of chlorination facilities and the unstable water pressures which are the result of haphazard developments and arrangements in the past (Wabana Municipal Plan, 1980-1990).

Approximately 680 acres or 9.8% of the Island's surface area is occupied by urban development and the remaining 6,130 acres or 90.2% of the total remain rural.

3.2 NATURAL ENVIRONMENT

3.2.1 General Characteristics

Bell Island is located in the Maritime Barrens ecoregion and the Northeastern Barrens subregion (Damman 1983). This ecoregion is characterized by extensive barren areas consisting mainly of dwarf shrub heaths, bogs and shallow fens. Forests are most common in valleys, but are occasionally on hill tops and slopes. Most of the forest cover in this ecoregion was eliminated by the combined effect of frequent fires, poor regeneration after these fires, the marginal climatic conditions for tree growth, and the strong competition from ericaceous dwarf shrubs. There does not appear to be any rare, threatened or endangered vegetation on the Island (Collins 1986).

Forests are more extensive in the barrens, and arctic-alpine species have a very restricted distribution. Table 3.1 lists vegetation normally found in the Maritime Barrens ecoregion. Of the 2,479 ha of rural land on Bell Island, 1,344 ha (48.7%) is classified as woodland or forest (Provincial Planning 1981). Twenty-four ha (0.9%) is classified as marsh or bog and 280 ha (10.2%) as unproductive land, which the open barrens and dwarf shrub heath vegetation would be classified (Provincial Planning 1981). The wooded area is chiefly spruce and balsam fir but trees are small and forestry has no commercial significance (Provincial Planning 1981).

Table 3.1 Vegetation Found in the Maritime Barrens Ecoregion

Scientific Name	Common Name	Habitat Type
Abies balsamea	Balsam Fir	Forest
Dicranum spp.	Broom Moss	Forest Floor
Rhytidiadelphus loreus		Forest Floor
Rhytidiadelphus triquestrus		Forest Floor
Hylocomium splendens	Mountain Ferm Moss	Forest Floor
Nemopanthus mucronata	Mountainholly	Throughout/Open Barrens
Viburnum cassinoides	Wild Raison	Throughout/Open Barrens
Larix laricina	Larch	Open Barrens
Sorbus decora	American Mountain-ash	Coastal
Sorbus americana	Showy Mountain-ash	Coastal
Kalmia angustifolia	Sheep Laurel	Dwarf Shrub Heath
Rhododendron candense	Rhodora	Dwarf Shrub Heath
Vaccinium angustifolium	Low Sweet Blueberry	Dwarf Shrub Heath
Pleurozium schreberi	Feather Moss	Dwarf Shrub Heath (Moss layer)/Forest
Cladina stellaris	Reindeer Lichen	Dwarf Shrub Heath (Moss layer)
Empetrum spp.	Crowberry	Dwarf Shrub Heath (Exposed sites)
Vaccinium vitis-idaea	Mountain Cranberry	Dwarf Shrub Heath (Exposed sites)
Gaylussacia dumosa	Dwarf Huckleberry	Bog
Habenaria blephariglottis		Bog
Schizaea pusilla	*Curlygrass*	Bog
Carex spp.	Sedge	Bog
Sphagnum spp.	Bog	

Source: Damman (1983)

3.2.2 Avifauna

The avifauna of Bell Island has not been studied specifically; however, the habitat is very similar to adjacent parts of the Avalon Peninsula for which its birds are well known. An accurate extrapolation of bird data from the Avalon Peninsula can be applied to Bell Island with complete confidence.

The wind turbine station is surrounded by a dense forest of balsam fir and black spruce 5-10m in height. Most of the area within a 750 m radius of the site is of this habitat type. This habitat covers 48.7% of the rural land on Bell Island. Birds typical of this habitat are in Table 3.2. More than 10% of the rural land is bog, open barrens and farm land. A small amount of this habitat is within 750m radius of the tower.

3.2.3 Other Wildlife

Other wildlife present on Bell Island are domestic animals (cows, horses, pigs, chickens, sheep, dogs and cats), with the exception of one moose (*Alces alces*) (D. Butler, pers. comm.). Rare, threatened or endangered species of wildlife have not been reported on the Island (Collins 1986).

Other wildlife which may be found on Bell Island include: little brown bat, beaver, meadow vole, muskrat, red fox, weasel, otter, masked shrew, snowshoe hare, red squirrel, Norway rat, house mouse, and mink.

3.2.4 Climate

The nearest data collection station to Bell Island is St. John's A at the Torbay Airport which is located approximately 16 km away. For the period 1951 to 1980, the yearly average of precipitation was 217 days with approximately 125 cm

Table 3.2 List of birds occurring within the study area

Common Name	Scientific Name	Habitat		Season	
		Wooded	Open	Sum.	Win
Osprey	*Pandion haliaetus*	X	X	X	-
Merlin	*Falco columbarius*	X	X	X	-
Common Snipe	*Capella gallinago*	X	X	X	-
Herring Gull	*Larus argentatus*		overhead		
Great Black-backed Gull	*Larus marinus*		overhead		
Downy Woodpecker	*Picoides pubescens*	X	-	X	X
Northern Flicker	*Colaptes auratus*	X	X	X	-
Yellow-bellied Flycatcher	*Empidonax virescens*	X	X	X	-
Horned Lark	*Eremophila alpestris*	-	X	X	-
Tree Swallow	*Iridoprocne bicolor*	X	X	X	-
Blue Jay	*Cyanocitta cristata*	X	X	X	X
American Crow	*Corvus brachyrhynchos*	X	X	X	X
Common Raven	*Corvus corax*	X	X	X	X
Black-capped Chickadee	*Parus atricapillus*	X	-	X	X
Boreal Chickadee	*Parus hudsonicus*	X	-	X	X
Golden-crowned Kinglet	*Regulus satrapa*	X	-	X	X
Ruby-crowned Kinglet	*Regulus calendula*	X	-	X	-
Swainson's Thrush	*Catharus ustulatus*	X	-	X	-
American Robin	*Turdus migratorius*	X	X	X	-
European Starling	*Sturnus vulgaris*	X	X	X	X
Yellow Warbler	*Dendroica petechia*	X	-	X	-
Yellow-rumped Warbler	*Dendroica coronata*	X	-	X	-
Blackpoll Warbler	*Dendroica striata*	X	-	X	-
Northern Waterthrush	*Seiurus noveboracensis*	X	-	X	-
Wilson's Warbler	*Wilsonia pusilla*	X	-	X	-
Savannah Sparrow	*Passerculus sandwichensis*	-	X	X	-
Fox Sparrow	*Passerella iliaca*	X	-	X	-
Swamp Sparrow	*Melospiza georgiana*	X	X	X	-
White-throated Sparrow	*Zonotrichia albicollis*	X	-	X	-
Dark-eyed Junco	*Junco hyemalis*	X	X	X	X
Pine Grosbeak	*Pinicola enucleator*	X	-	X	X

annually (Environment Canada 1982), higher that in most of Canada. There were 156 days of rain and 88 days of snow. The mean daily minimum temperature for January was -7°C and the mean daily maximum temperature for July was 21°C. Based on a 26 year record (1955-1980) the prevailing wind direction for the St. John's area is west southwest from April to October for 17% of the year. The average wind speed is 24.3 km/hr with maximum gusts of 193 km/hr. The Island lies completely unprotected from winds coming from all directions (Provincial Planning Office 1981).

The Northeastern Barrens subregion has a warmer summer and lower fog frequency than the other subregions of the ecoregion except for the Central Barrens subregion.

Conception Bay is open to navigation for the greater part of the year, but occasionally it is blocked by slob ice from the north during the winter months, at which point air service becomes the only means of transportation to and from the island. Generally transportation is available via Ferry between the beach and Portugal Cove.

3.3 PHYSICAL ENVIRONMENT

3.3.1 Noise Levels

Significant noise levels in any area are usually generated by such sources as industry, aircraft and surface traffic. Since the closure of the mine, industry has not been an issue on the Island.

There has been no Noise Exposure Forecast (NEF) map (i.e. a map which shows the contours in which a given land area is affected by airplane noise) compiled for Bell Island; however, if one projects from the map done for the airport and

environs it looks as if Bell Island, including the wind turbine demonstration site, would be affected by the 15 or 20 NEF contour.

3.3.2 Land Use

The history of Bell Island iron ore mining spans the years 1894-1966, although its resources have been known since at least the early 17th century. John Guy (Cell 1982:64) mentions the presence of an iron mine on "Belile" in a letter to England written in 1610.

Since the mines closed there has been little industry on the island. In the early 1970s a successful experiment to grow mushrooms was instigated by Stephen Neary, local M.H.A., but there was no financial backing for the project. Many parks have been built around the island to attract visitors and guided tours of the mines have been suggested as an added attraction. After the closing of the mines it was proposed that crude oil be stored in the mines, but up to 1981 nothing had been done about this idea. It has also been suggested as recently as 1988 that the mine shafts on Bell Island be used to store treated PCB waste from all across Canada, but this idea has run into significant opposition.

Residential areas encompass dwelling units and their associated lots. Residential land constitutes approximately 453.3 acres or 6.6% of the Islands surface area, and is predominantly located in the northeastern half of the Island within the municipal boundary of the town of Wabana. There are also clusters of residential land in the smaller settlements of Lance Cove, Bickfordville, and Freshwater which are on the southwestern half of the Island. The general pattern of residential use has apparently changed very little during the past ten years while residential density has decreased considerably since the closure of the mining operations in 1966. This decrease in density was mainly the result of the policy of removal and demolition established and implemented after the closure of the mines.

The principal commercial components on the Island are retail, wholesale and commercial businesses. The majority of commercial establishments are concentrated within the town of Wabana; however, there are a few to be found in the smaller settlements. Commercial lands account for approximately 115.4 acres or 1.7% of the Island's surface area. As a result of the population decline and economic setback during the last decade, a number of commercial buildings have been vacated in some districts. Existing commercial establishments on the Island include the following:

22 retail stores
1 grocery wholesale outlet
2 service stations
1 garage
1 bank
1 medical clinic
5 lounges, clubs, and restaurants
4 other commercial establishments

The history of mining on the Island has been one of prosperity versus collapse between the years 1894 and 1966 when competition from new producers who could mine iron ore less expensively gradually led to a decline in markets for Bell Island ore. Following the closure of the mines in June, 1966, industrial use of the Island became minimal. Currently, the only industrial uses are the wharf facilities located along the southeastern shoreline and the nearby gasoline storage sites. They account for about 6 acres or 0.1% of the Island's surface area.

Institutional land embraces a number of land uses that are essentially devoted to public services. Included are lands utilized by the three levels of government, schools, churches, hospitals, and other public or semi-public organizations.

Institutional land use exists mainly within the town of Wabana and occupies approximately 72.7 acres or 1.0% of the Island's surface area.

Recreational open space includes parks, picnic areas, playgrounds, playing fields, and sport facilities. Aside from those areas attached to schools, recreational open space lands occupy approximately 26.8 acres or 0.4% of the Island's surface area.

All land not included in the previous use categories is considered to be rural and it represents 6,126.6 acres or 90.2% of the Island's surface area. However, less than 1.0% of the rural area was devoted to agricultural purposes in 1975. Detailed classifications of the Island's rural land are shown in Table 3.3.

Approximately 680 acres or 9.8% of the Island's surface area is occupied by urban development and the remaining 6,130 acres or 90.2% of the total remain rural (Provincial Planning Office 1981).

3.3.3 Communication Signals

The existing communication signals making up the electromagnetic environment on Bell Island are essentially the same as those in St. John's. The majority of television and FM/AM band frequencies transmitted from St. John's are received clearly. The local cable television channels are received by satellite.

The telephone communication signals consist of two microwave towers operated by Newfoundland Telephone. One tower is used for normal telephone services, while the other is used for cellular phone services.

Table 3.3 Classification of Rural Land, Bell Island, 1975

CLASSIFICATION	AREA (ACRE)	PERCENT OF TOTAL
Woodland	3,320.6	48.7
Unproductive Land	691.8	10.2
Rough Pasture	687.1	10.1
Scrub Grassland	682.9	10.0
Improved	521.6	7.7
Water	110.3	1.8
Marsh and Bog	60.0	0.9
Cropland	47.3	0.7
Horticultural	5.0	0.1
TOTAL	6,126.6	90.2

3.4 SOCIAL ENVIRONMENT

3.4.1 Human Population

It is generally believed that Bell Island was frequented by European fishermen and pirates as early as the Sixteenth Century (Encyclopedia of Newfoundland and Labrador, 1981) but the first recorded permanent settler on Bell Island was Gregory Normore (1717-1783), a native of Jersey in the Channel Islands. Many of the first settlers on Bell Island were of Irish and English extraction.

The population of the Island is 4608 of which 4056 live in the town of Wabana (D. Butler personal communication). Wabana developed in the tradition of a camp rather than a town because most of the people who worked there had homes elsewhere but often more permanent dwellings developed as a result of the convenience of living near the mine site.

The inhabitants of the island make their living in a number of ways: some commute to jobs in and around the St. John's area, and some are employed in health, education and service jobs. Still others farm or fish.

4.0 IMPACTS

4.1 RESIDENTIAL QUALITY OF LIFE

4.1.1 Socio/Economic

Results for this section were to come from a public information survey to be taken throughout Bell Island. This component of the report was designed to determine the level of acceptance of the installation by the general public. As the project

was stopped before the survey was initiated the survey questionnaire is included in Appendix A for possible future reference.

4.1.1.1 Employment

The implementation of a wind energy conversion system would create both permanent and temporary employment. The installation and construction of a wind energy machine represent temporary job creation. The number of jobs created would depend on the extent of development of the Wind Energy Conversion (WEC) system (British Wind Energy Association, 1982).

There is insufficient experience in Canada to have learned the actual employment benefits of wind turbines and wind turbine arrays. However, as a general rule about 6-10 permanent technical, clerical, and supervisory jobs are considered likely to be created for each 10 MW or 100 machines. This seems to be the point at which the economics for maintenance and operation begin to become attractive (Malcolm Lodge, personal communication, 1990).

Of the available research reports which investigated wind energy and employment most conclude significant positive impacts resulting from the implementation of wind power on a large scale. In a research report on net energy and jobs from wind energy D. Bain (1978) reported a significant impact on the U.S. economy resulting from large scale wind energy programs. Many of the new jobs would be in the fields of production, service and maintenance.

4.1.1.2 Tourism

There is a definite tourism element to the construction of large turbines or wind farms, particularly when they are placed in locations which are relatively easily accessible and which have other drawing features in the nearby regions. At the

Atlantic Wind Test Site in Prince Edward Island 3-4,000 people generally visited the site with little advertising and promotion. During the past two summers, following the construction of a 100 seat seafood restaurant only a few hundred metres from the test field in excess of 12,000 people visited the site. As a result the Atlantic Wind Test Site has been able to gain funding to operate a higher level of interpretative program for the Site. In this regard, the test site and the restaurant are enjoying the mutual benefits of higher exposure and greater business (M. Lodge personal communication 1990).

4.1.1.3 Health and Safety

Health and safety concerns during operation of a wind energy system are most likely caused by three conditions:

- structural failure;
- electrocution (as with transmission towers); and
- ice thrown or falling from the blades.

Safety concerns regarding structural failure of wind energy systems most often relates to the structural integrity of rotating structures which are exposed to the elements. In a report on design considerations and component design requirements the rotor was described as the key component of any wind energy conversion system and its failure has the most serious impact on the safety of life and property (Canadian Standards Association, 1985).

Ice is of a safety concern in areas where ice storms occur regularly. Damage can occur to structures and people in the vicinity of the wind turbine from ice thrown or falling from a machine. Acres International has investigated in detail the climate relating to ice buildup for the Bell Island area and the probable trajectories for thrown ice. This information is included in Appendix B.

4.1.1.4 Economy

The effect of these machines on the local economy is not a well documented subject. Before a wind turbine industry becomes economically feasible it has to be an appropriate size, i.e. about 50 machines. In Denmark where there are many groups of a small number of turbines connected to grids, the economic situation is different because of the existence of tax credits.

4.1.2 Noise

Acres International was to collect data from the site both when it was shut down in order to measure ambient noise levels and again when the turbine was operational. This information was to be used to forecast the cumulative effects of multiple units.

Two noise sources are recognized, namely, aerodynamic noise from turbine blades and generator noise.

A wind turbine generator may produce noise with both impulsive ("thumping") and broadband ("swishing") characteristics. The low-frequency impulsive noise tends to be the most annoying because it dominates other sources and can cause structures to shake. However, not all types of machines produce this noise.

Modern wind turbines produce very little noise and, in fact, can often not be heard at all unless the listener is very close to the machine where the blades make a swishing sound as they pass through the air. However, researchers continue to address public concern, particularly in the United States, about wind turbine acoustics (SERI 1988).

One obvious concern resulting from a real or perceived increase in noise levels would be the reduction in the rental or purchase values of living quarters.

4.1.3 Aesthetics/Visual

The results from a small scale survey done in California in 1988 show a marked disparity between the perception of the general public toward wind turbines and that of regulators in the industry (Davidson, WINDPOWER MONTHLY 1988).. Most regulators agree that wind power is reliable and that windfarm development is less environmentally disruptive than other energy projects and should be encouraged. Amongst the general public, however, wind power was seen as causing fewer environmental problems than nuclear or fossil fuel energy but more problems than imported power, hydro or solar power. One of the greatest environmental impacts was perceived to be the visual impacts.

According to Robert Thayer, chair of the Department of Environmental Design and a professor of landscape architecture at the University of California Campus in Davis, California that public perception of wind turbines in the United States, and particularly in California, is the major hurdle facing the industry - more so even than technical or economic issues. "Perfectly sound projects are being shut down on visual grounds" he notes (WINDPOWER MONTHLY, Vol. 3, number 10).

The three main kinds of towers are lattice, conical and guyed conical and the most visually accepted of the three when at a distance is the lattice tower because the general effect is of being able to look through the tower (and it would probably be the case that when the blades are rotating that they can't be seen either). Up close, however the conical towers are thought to be more visually acceptable (Lodge personal communication 1990).

A survey conducted in the USA (Ferber, 1977) assessed the public response to wind turbine designs via slides. The results indicated a strong preference for "Dutch-style" windmills as compared to horizontal axis propeller type wind turbines on a column tower or a lattice tower, vertical axis Darrieus, and giromill turbines. It seems from this study that the more informed, educated or wealthy the respondents, the more likely they were to have some knowledge of WECS and to view them sympathetically. It was suggested that colour design of a wind turbine could assist in creating pleasing aesthetic reactions, however good design is generally attractive in its own right. The types of aesthetic qualities one might try to maintain in a design are: clarity of operation, apparent simplicity of structure and visual reassurance of the safety or containment of the rotor. The first few WECS in an area seem to have considerable novelty value, and at some locations they have been considered as tourist attractions; however, as the novelty value wears off and the number of turbines goes up, public reaction to the visual impacts of wind turbines may become more critical.

It is also important to recognize the possibility of some optical effects (shadow for example) generated by a rotor that may have adverse effects on human behaviour in the vicinity of WECs (British Wind Energy Association-BWEA 1982).

It has often been argued that a cleanly designed wind turbine is no more offensive to the eye than transmission towers or telephone and electric light poles along a roadway. Cleanly designed machines such as the Carter 300 with smooth aerodynamic lines and low solidity are considered to have much less visual impact than are designs with many struts, braces, and high solidity shapes with sharp edges and corners (Lodge personal communication 1990).

4.1.4 Electromagnetic Interference (EMI)

The main concern regarding EMI would be that the rotating blades of a horizontal-axis wind turbine would distort the video portion of a television signal and thereby interfere with reception in the vicinity of the machine. Interference would decrease with distance from the machine but it can still affect the upper (high frequency and number) UHF television channels at distances of several kilometres. The audio portion is not affected by rotor blades (Cingo, 1980). Even when the blades are stationary, the scattered signal may appear on the television screen as a ghost (SERI 1988). From what we can understand so far this is probably not a concern on Bell Island or in Newfoundland.

In relation to FM/AM radio and aircraft navigational systems, no significant interference should result from rotating blades (Cingo, 1980). Guidelines have also been developed to position wind turbines in order to produce negligible impacts on microwave communications (Cingo, 1980).

No complaints have been registered with NL&P regarding the potential hazard created by the tower to aircraft. The effect of a wind rotor on navigational aids, such as Instrument Landing Systems, and on the reception of emergency or distress information is not thought to be significant (Report of the Wind Energy Technical Panel of the UN Conference on New, and Renewable Sources of Energy, 1980).

4.1.5 Land Use

In a study of the application of wind energy in Alaska, concern was expressed regarding the possible damage caused by installing a WECS structure on the arctic tundra. The possibility of tundra and other land surface damage should be taken

into account during transportation of heavy equipment to a WECS site and for the installation and maintenance of the WECS.

A Bureau of Reclamation study concluded that wind powered generators spaced about 10 rotor diameters apart would occupy less than 1% of the total projected land use for a wind farm, thus allowing use of the rest of the land for grazing or farming (Journal of Environmental Sciences, Nov-Dec 1980, No.6).

According to Hohmeyer (1988) the occupation of land is thought to be a very minor effect, because the land below the turbines may still be used for grazing cattle (CONAES 1979, p.370 and practical US and Danish experience). Hohmeyer also claims that there has been no evaluation of the aesthetic costs which may result from the spoiling of the landscape by wind energy parks.

4.2 NATURAL ENVIRONMENT

As the proposed project has been stopped not all aspects of this component have been completed.

Through general investigations it was noted that the turbine site was built on a former mine tailings area which is of no significant agricultural or environmental value. If the site were to expand into an area that did have agricultural or environmental value, careful consideration would have to be given to the special requirements of this land.

The effects of noise on wildlife vary considerably between species. These differences reflect their hearing sensitivities, thresholds at which panic or startle responses are elicited, their ability to habituate to noise and their ability to withstand or compensate for increased energy expenditures and physiological stress associated with noise disturbances. The capability of a species to habituate

is dependent on their perception of whether a particular noise is threatening (a predator threat for example) or whether it is neutral. These concerns generally become an issue only when dealing with aircraft noise and sonic booms which would be well beyond the decibel levels we must be concerned with; however, the possible effects may be along similar lines.

4.2.1 Avifauna

One of the main concerns is the possibility of birds, especially raptors and migratory birds, striking the rotating blades of a wind turbine. There are many conflicting reports, some suggesting that bird strikes are of no concern, others citing it as a major problem sometimes resulting in the need for fairly drastic mitigation. This wide a dichotomy in the perception of the problem may be a result of the specific characteristics of the sites from which these reports emanate. That is, if the site is close to or on a nesting or migratory route the potential for problems becomes much greater than if the windfarm is not affected by these or similar considerations.

Nearly 100 birds are reported to have been killed since 1986 in Altamont California, by flying into wind turbines. A number of the deaths involved raptors and several of these involved rare species. As a result of the fatalities, the California Energy Commission performed a study of avian mortalities resulting from collision or electrocution involving wind energy related structures. Incidents compiled and analyzed covered the period from November 1984 until April 1988, and involved the two major wind resource areas in California-Altamont Pass in Alameda and Contra Costa Counties, and Tehachapi Pass in Kern County. The documented accidents involved 108 raptors from seven species. Ninety percent of the accidents resulted in the bird's death and of these 72 involved collisions. The most frequently reported collision victims were golden eagles and red-tailed

hawks. Incidents occurred throughout the year, but peaked during December and January.

Electrocution at powerlines was involved in 36 incidents. These all occurred in the Altamont Pass area. The study could not determine which wind turbine component-rotor, tower, guy wire, generator or associated powerline-was responsible for the collisions. The American Wind Energy Association (AWEA) claimed, in defence, that "The environmental impact from wind technology is dwarfed in comparison with...birds' collisions with large structures (such as bridges, buildings, and communication towers)...". The California Energy Commission tends to agree, saying that avian collisions with human constructs has been a concern for over a century. However, the Commission also points out that many of the wind energy sites in California are in areas used by migrating, nesting, and wintering birds.

4.2.2 Other Wildlife

Given that the project was stopped the field survey was not conducted. The purpose of the survey was to determine the wildlife species present on Bell Island and potentially affected by the wind turbine.

Research into the effects of a wind turbine on wild and domestic mammals has been limited to library searches. At this time, data are very limited.

4.2.3 Domestic Animals

Domestic animals make up the majority of animals found on Bell Island. The public information survey (Appendix A) was to address the potential of any impacts to domestic animals.

5.0 MITIGATION

As no primary information was collected regarding any impacts of the wind energy system on Bell Island, this section will be limited to mitigation measures discussed in the relevant literature collected.

There are a number of areas where mitigation may be necessary to address correct existing or potential impacts. Sometimes, fairly small scale changes in approach or operation can have very positive effects on environmental problems; occasionally, more drastic measures may be required.

5.1 SOCIO/ECONOMIC

It would appear that many of the impacts involving people have the potential to be positive; the main negative ones are visual and noise interference. The building of wind turbine sites in remote areas would reduce this problem; however this does not solve the problem altogether and often presents additional concerns.

5.1.1 Health and safety

If required by the owner, local regulations and/or codes, the WECS support structure or tower installation should incorporate an anti-climbing design or the site should be secured. All ground level equipment should be lockable and suitable graphic and textual warning signs should be provided. Warning signs should be placed for "High Voltage", "Buried Cables Here", "Turbine Starts Automatically", "Tower Climbing is Restricted to Authorized and Trained Personnel", or similar approved warning signs.

Ladders should comply with safety requirements. Where access for servicing or maintenance requires a person to balance on a narrow or steep sloping surface,

provision should be made for securing a lifeline and safety belt or other approved protective device.

There are mitigative measures available to counteract structural failures:

- Rotors Flying Off: Maximum wind speed tolerance changes with models. All models ought to have methods of preventing damage as winds increase. Some models, including the WEC-23, have vents that will turn out of the wind as pressure increases. The design and weight of the fibreglass blades ought to result in a near vertical fall with little resultant damage to surrounding property. As a basic rule, clearance generally equals the height of the tower.

- Towers Blowing Over: High stresses result from the rotation of the rotors and from wind. Local regulations specify required clearance around towers.

- Wiring: Good quality wiring, properly installed by experienced electricians is required.

5.2 NOISE

Building at an appropriate distance from habitation sites is one way to reduce the level of annoyance from the noise produced by wind turbines.

The effects of wind turbine noise on the listener may be modified by factors such as the background noise level, location of the listener (indoors/outdoors), and the presence of any perceptible house vibrations induced by the noise. Any noise from a wind turbine tends to be masked by the noise of the wind itself, and of

course, the machines do not run when wind is absent (Solar Energy Research Institute-SERI 1988).

5.3 AESTHETICS/VISUAL

Blending the turbine structure, related structures, and enclosure design with the surrounding environment may have positive results when attempting to limit the visual impact of turbines.

Visual, as well as other impacts may also be mitigated somewhat by use of exhibits, tours and brochures to educate the public as to the value of windfarms.

5.4 ELECTROMAGNETIC INTERFERENCE (EMI)

There are conflicting reports on the problem of electromagnetic interference; however, it would appear that the problem is minimized by the use of fibreglass blades. It is maintained that there is minimal electromagnetic interference when using fibreglass blades because the electromagnetic waves pass through the fibreglass (J. Carter, pers. comm.). This view is substantiated by the British Wind Energy Association (BWEA) who maintain that different materials reflect signals with a variety of efficiencies, and that fibreglass and wooden blades will have less effect on signals than steel or aluminum blades. The BWEA also suggest that interference might be significantly reduced by the use of directional aerials and that local land features could increase or decrease interference.

5.5 NATURAL ENVIRONMENT

Since no field study was conducted due to project cancellation, this section has not been investigated.

6.0 ALTERNATIVE SITES

It is difficult to say exactly which areas of Newfoundland or Labrador would be best for a wind turbine farm. Of the many variables which need to be considered, the environment is only one. In choosing a site certain areas should be avoided; any areas that would intrude upon the habitat of endangered species; archaeological sites or areas of high potential for archaeological sites; agricultural and farm land; or any areas of particular natural or social significance.

7.0 MULTIPLE UNITS

Some wind tunnel tests have been done in Sweden to determine the minimum permissible spacing of wind rotors in a given geographical area to prevent significant interaction of the rotors that could result from the windstream turbulence created by the rotors. From this work, it appears that the spacing should be at least 6 rotor diameters, and that an 8 to 12 diameter spacing may be most desirable.

Potential areas of concern regarding the natural environment may include intrusion on agricultural space or environmentally sensitive areas resulting from expansion of the present facility.

Any consideration for expanding the present wind demonstration site or, in particular, for developing a wind farm in some other part of Newfoundland or Labrador, would have to involve a thorough investigation into the value of the area as habitat or for any possible environmental significance.

8.0 CONCLUSIONS

Given the limited extent of the literature search and field surveys, and the cancellation of the project, no conclusions can be addressed.

9.0 REFERENCES *

* This list represents the complete literature search and not all have been cited in the report.

1) WILDLIFE

Blokpoel, Hans, 1976. Bird Hazards to Aircraft. Problems and Prevention of Bird/Aircraft Collisions.

British Wind Energy Association, 1982. Wind Energy for the Eighties.

Davidson, Ros, WINDPOWER MONTHLY, U.S.. Volume 4, Number 5, 1988. Bird Study Could Clip Wings of Operators.

_____, WINDPOWER MONTHLY, U.S.. Volume 3, Number 10, 1987. Environmental Issue In Need Of Reality Not Romanticism.

Electric Light and Power, February, 1990. Birds Endangered by Wind Turbines.

Electric Power Research Institute, 1984. Solano County MOD-2 Wind Turbine Field Experience. Interim Report.

Electric Power Research Institute, 1985. MOD-2 Wind Turbine Field Experience in Solano County, California. Final Report.

Pedersen, Tom, n.d.. Vestas Wind Systems. Wind power: cost effective generation for the 1990's.

South, Robin G., editor, 1983. Biogeography and Ecology of the Island of Newfoundland. Dr. W. Junk Publishers. The Hague-Boston-London.

Van Beek, Jos, 1989. Developers Strike Deal with Bird Societies. Windpower Monthly News Magazine. Volume 5, Number 12 and Volume 4, Number 5.

Windpower Monthly, Volume 6, Number 1, 1990. No Verdict Yet On Birds Issue.

_____, Volume 5, Number 10, 1989. Seldom do birds fly into houses.

2) NATURAL ENVIRONMENT

British Wind Energy Association, 1982. Wind Energy for the Eighties.

Collins, G. 1986. Plants and animals which are rare, threatened or endangered within the Island of Newfoundland - Provisional Notes. Technical Bulletin of the Newfoundland Museum, No. 4. 172 pp.

Damman, A.W.H. 1983. An ecological subdivision of the Island of Newfoundland. *In:* G.R. South (ed.). Biogeography and Ecology of the Island of Newfoundland. Dr. W. Junk Publishers, The Hague. 723 pp.

Encyclopedia of Newfoundland and Labrador, 1981. Volume 1 pp. 167-169. Joseph R. Smallwood, editor in chief. Robert D. W. Pitt Managing editor. Newfoundland Book Publishers, St. John's, Newfoundland.

Environment Canada. 1982. Canadian Climate Normals 1951-1980 - Volume 5 Wind. Atmospheric Environment Service, UDC:551.582.2(71). 283 pp.

Environment Canada. 1982. Canadian Climate Normals 1951-1980 - Temperature and Precipitation Atlantic Provinces. Atmospheric Environment Service, UDC:551.582(715/9). 136 pp.

Pedersen, Tom, n.d.. Vestas Wind Systems. Wind power:cost effective generation for the 1990's

Provincial Planning Department, Department of Municipal Affairs, Hazel Newhook, Minister, 1981. Wabana Municipal Plan: Ten Year Plan, 1980-1990.

Provincial Planning Office. 1981. Wabana Municipal Plan 1980-1990. Prepared for The Town of Wabana by Department of Municipal Affairs and Housing. 129 pp.

3) NOISE

Allen, G.M., Michael Brandman Associates, Inc. n.d.. Wind Farm Noise Issues and Impacts.

Bruijn, A. de, Institute of Applied Physics, Netherlands and W.J. Stam, Netherlands Energy Research Foundation, and W.B. de Wolf, National Aerospace Laboratory, The Netherlands, 1984. Determination of the Acoustic Source Power Levels of Wind Turbines.

Electric Power Research Institute, 1984. Solano County MOD-2 Wind Turbine Field Experience. Interim Report.

Electric Power Research Institute, 1985. MOD-2 Wind Turbine Field Experience in Solano County, California. Final Report.

Ljungren, Sten and Anders Gustafsson, FFA, The Aeronautical Research Institute of Sweden and Andrew R. Trenka, Wind Systems Branch Rockwell International, editors, 1984. Recommended Practices For Wind Turbine Testing: Acoustics. Measurement Of Noise Emission From Wind Energy Conversion Systems (WECS).

Lukas, Jerome S., 1975. Noise and Sleep: A Literature Review and a Proposed Criterion for Assessing Effect.

Newham, Mark, WINDPOWER MONTHLY, U.K., June, 1988. Projects Threatened By Noise Report.

Pedersen, Tom, n.d.. Vestas Wind Systems. Wind power: cost effective generation for the 1990's

Shepherd, K.P., The Bionetics Corp., Hampton, VA. and H.H. Hubbard, The College of William and Mary, Williamsburg, VA. n.d.. Environmental Noise Considerations For The Siting and Operation of Wind Energy Farms.

Solar Energy Research Institute, 1988. Wind Power...Today's Energy Option. Colorado.

Solar Energy Research Institute, 1989. Wind Energy, Technical Information Guide. Colorado.

Van der Borg, N.J.C.M. and W.J. Stam, 1987. The Acoustic Source Power of Wind Turbines.

Walker, Celano and Associates, 1988. Acoustic Measurement Report WECS Noise Emissions Tests Carter Wind Systems Model 300N.

Wind Energy for the Eighties, 1982. British Wind Energy Association.

4) INTERFERENCE WITH COMMUNICATION SIGNALS

British Wind Energy Association, 1982. Wind Energy for the Eighties.

Electric Power Research Institute, 1985. MOD-2 Wind Turbine Field Experience in Solano County, California. Final Report.

Energy, Mines and Resources Publication Canada. Conference Proceedings, November 26-29, 1989. Energy Issues and Alternatives for Newfoundland Remote Communications.

Hignell, R.J.C., n.d.. Electromagnetic Interference From Wind Energy Conversion Systems-Preliminary Information.

Hohmeyer, Olav, 1988. Social Costs of Energy Consumption: External Effects of Electricity Generation in the Federal Republic of Germany. Commission of the European Communities.

Newfoundland Telephone Company Limited, n.d.. Cycle Change and Wind Turbine Demonstration Project Newfoundland Telephone Company Limited.

Solar Energy Research Institute, 1989. Wind Energy, Technical Information Guide. Colorado.

Wind Energy Technical Panel of the UN Conference on New and Renewable Sources of Energy, 1980 Report.

5) SOCIO/ECONOMIC

British Wind Energy Association, 1982. Wind Energy for the Eighties.

Cell, Gillian. 1982. Newfoundland Discovered: English Attempts at colonization 1610-1630. Hakluy and Society, London.

Cingo, R.P., Rockwell International, 1980. In Journal Of Environmental Sciences Volume 23, Number 6, Pages 11-15.

Cleveland, Bradley, WINDPOWER MONTHLY. Volume 2, Number 3, 1986. Oppositions to Windpark Development.

Collins, Sue, Special Correspondent, U.K. for WINDPOWER MONTHLY. Volume 4, Number 10, 1988. Enemy is CEGB Not Wind Power say Environmentalists.

Committee on Nuclear and Alternative Energy Systems (CONAES): Energy in Transition 1985-2000. San Francisco, 1979.

Davidson, Ros, WINDPOWER MONTHLY, U.S.A..Volume 4, Number 10, 1988. Ugly and Unnecessary Says Opposition.

Encyclopedia of Newfoundland and Labrador, 1981. Volume 1 pp. 167-169. Joseph R. Smallwood, editor in chief. Robert D. W. Pitt Managing editor. Newfoundland Book Publishers, St. John's, Newfoundland.

Energy, Mines and Resources Publication Canada. Conference Proceedings, November 26-29, 1989. Energy Issues and Alternatives for Newfoundland Remote Communications.

_____, n.d.. Wind Energy Conversion Potential of Remote Communities on the Labrador Coast.

Hall, J.S., 1986. The General Health Effects of Noise on Man. In: North Atlantic Treaty Organization; Committee on the challenges of Modern Society, Number 161. Aircraft Noise in a Modern Society. Proceedings of a Conference held at Mittenwald (Germany) 22-24 September, 1986.

Hohmeyer, Olav, 1988. Social Costs of Energy Consumption: External Effects of Electricity Generation in the Federal Republic of Germany. Commission of the European Communities.

Minutes of Bell Island Wind Farm Project Review Committee Meeting. October 4, 1988, Murray's Pond.

Moller, Torgny, WINDPOWER MONTHLY. Volume 1, Number 7, 1985. Employment Outlook in the WECS Industry.

Pedersen, Tom, n.d.. Vestas Wind Systems. Wind power: cost effective generation for the 1990's.

Welsh, Melinda, WINDPOWER MONTHLY. Volume 1, Number 7. 1985. Rapidly Expanding Employment In Wind Industry.

6) CLIMATE

Chaine, P.M. and P. Skeates, Environment Canada, 1974. "Ice Accretion Handbook (Freezing Precipitation)".

Energy, Mines and Resources Publication Canada. Conference Proceedings, November 26-29, 1989. Energy Issues and Alternatives for Newfoundland Remote Communications.

Environment Canada, Principal Station Data, 1983. St. John's Torbay A.

McKay, G.A. and H.A. Thompson, "Estimating the Hazard of Ice Accretion in Canada from Climatological Data", J. of Applied Meteorology, V.8, No. 6, December, 1969.

Sonder, Niels, WINDPOWER MONTHLY, Statistics. Volume 3, Number 12, 1987. Storms Stop Turbines.

Weather Engineering Corporation of Canada Limited, Ice and Wind Loading Study, Cross Island Diversity Project, Report prepared for Newfoundland Telephone, May, 1984.

7) TECHNICAL

American Wind Energy Association, 1988. Wind Energy Conversion Systems.

Canadian Standards Association, 1985. Small Wind Energy Conversion Systems (SWECS)-Safety, Design, and Operation Criteria: Solar and Wind Energy.

Chappell, M.S. October 1986. National Research Council of Canada. Program Report. Wind Energy Research and Development at the NRCC, 1975-1985.

Eldridge, Frank R, Van Nostrand Reinhold Company, Metrek Division, 1980. Wind Machines, 2nd Edition.

Government of Newfoundland and Labrador, Department of Mines and Energy and Acres International Limited. n.d.. Wind Power in Newfoundland and Labrador.

Moller, Torgny, WINDPOWER MONTHLY, Denmark. Volume 3, Number 5, 1987. Runaway Prompts Safety Talks.

Solar Energy Research Institute, 1989. Wind Energy, Technical Information Guide. Colorado.

WINDPOWER MONTHLY. Volume 3, Number 1, 1987. Parachutes Fail On Wincon Runaway.

8) VISUAL

9) LAND USE

Cell, Gillian. 1982. Newfoundland Discovered: English Attempts at colonization 1610-1630. Hakluy and Society, London.

10) MISCELLANEOUS

Bolcso, Stephen, 1989. Energy Alternatives: Looking Forward.

Energy Mines and Resources, Canada, 1986. In Renewable Energy Projects Digest 1985-1988.

Hunter, Monty. 1989. Bell Island Wind Demonstration Project Case Study. Paper on file with NLP Co. Limited, St. John's, Newfoundland.

McCutcheon, Sean, Government of Canada, n.d.. Exploring Energy-1: Wind Energy.

Newham, Mark, WINDPOWER MONTHLY, U.K., Volume 4, Number 10, 1988. Lords Chastise Europe Policy Makers.

Selzer, H.,1986. Wind Energy. Potential Of Wind Energy in the European Community. An Assessment. Brussel.

10.0 PERSONAL COMMUNICATIONS

American Wind Energy Association

Ancona, Dan. U.S. Department of Energy, Wind Energy Division.

Brady, Sheila. Wagstaff and Brady, California.

Butler, Diane. Town Hall, Bell Island.

Carpentier, Monique. Energy Mines and Resources, Ottawa.

Carter, Jay. International Wind Systems, Texas.

Conran, Bernadine. Memorial University of Newfoundland.

Driscoll, Don. Mines and Energy, Newfoundland.

Eddie, Rosemary. Provincial Department of Municipal Affairs.

Electric Power Research Institute, California Energy Commission.

French, Graham. Shawmont, Newfoundland.

Graham, Philip. Energy Mines and Resources, Newfoundland.

Hayes, Mary. Memorial University of Newfoundland.

King, Dawn. Canada Mortage and Housing Corporation, St. John's.

King, Geraldine. Provincial Department of Municipal Affairs.

Hunter, Monty. Newfoundland Light and Power Co. Limited, Newfoundland.

Lodge, Malcolm. Resource Ventures, Prince Edward Island.

Lynette, Bob. Lynette and Associates, Washington state.

Ryan, Bob. Provincial Department of Forestry and Agriculture, Newfoundland.

Stoyles, Maralyn. Town Hall, Bell Island.

Varghese, Mary. Mines and Energy, Newfoundland.

APPENDIX A

Draft Survey Questionnaire

Draft questionnaire for the Newfoundland Light and Power Co. Bell Island Wind Turbine Demonstration Project

1. a. Resident____, Visitor____, Tourist_____?

   b. What is the purpose of your visit? *(For visitors and tourists only)*

2. a. Are you aware of the experimental wind turbine located on the island?
   Y_____ N_____

   b. How did you hear about the site?

Newfoundland Light and Power Co. in conjunction with the Federal Department of Energy, Mines and Resources have installed a 300kw wind turbine on a site near Cummings Lane. They hope to identify the potential for grid connected wind turbines here in Newfoundland; assess the performance of such turbines in Newfoundland climate; evaluate the economic aspects of the project; evaluate the reliability of wind generation; investigate the possibility of any environmental impacts that may be associated with such an installation; and provide information and technology to interested parties.

3. a. Have you seen the wind turbine?
   Y____ N____

   b. If yes, how often?

   c. Is it near where you live? *(for residents only)*

   d. Have you made a point of visiting the site?

   e. Would you visit the site again?

   f. In your opinion would added facilities make the area more attractive?

   g. How did you hear about the site?

4. a. Are you familiar with the operation and maintenance of this structure?
   Y____ N____

5. a. Do you think a project such as this wind turbine could have economic benefits?
Y____ N____

b. How so?

6. a. What was your initial reaction to the structure?

b. Has this reaction changed in the past year?

7. a. Are you aware of any wildlife that regularly visit this area?
(the list will be attached and available for use if needed)
Y____ N____

b. If yes, can you identify them?

8. a. Are you aware of wildlife utilizing this area in the past?
Y____ N____

b. If yes, can you identify them?

9. a. Since the initial operation of the turbine have the numbers of wildlife in the area:

remained about the same

increased slightly
moderately
significantly

decreased slightly
moderately
significantly

10. a. Have you observed birds flying near the structure?
Y____ N____

b. If yes, can you identify them?

11. a. Have you noticed any dead birds on the ground near the turbine?
Y____ N____

b. If yes, can you identify them?

12. a. Are you aware of domestic animals utilizing this area in the past?
Y____ N____

b. If yes, do they still use it?

13. a. Since the initial operation of the turbine have the numbers of domestic animals in the area:

remained about the same

increased	slightly
	moderately
	significantly
decreased	slightly
	moderately
	significantly

14. a. Have you noticed any sound associated with the wind turbine?
Y____ N____

b. If yes, can you describe the sound?

c. When is this sound most noticeable?

d. Can the sound be detected from within your home?

not detectable

mildly detectable

extremely detectable

15. a. Do you have any concerns regarding safety around the structure?
Y____ N____

b. If yes, what are they?

16. a. Do you perceive that the existence, operation and maintenance of the structure would have an effect on the health of the people living near the structure?
Y____ N____

b. If yes, explain.

17. a. Do you have a television? Y____ N____
telephone? Y____ N____

b. Have you experienced any interruptions in the above services in the past year?
Y____ N____

If yes;

c. With ? _____

d. When ? _____ *(looking for dates, times (am, pm)...)*

e. Can you describe these interruptions?

18. Should Newfoundland Light and Power Co. decide that it would be feasible to operate a number of turbines in the general area what would your reaction be?

Observations:

APPENDIX B

Ice Buildup for Bell Island and Probable Trajectories for Thrown Ice

To date our research has indicated that the main concerns caused by the local climate include:

- High Winds: All parts of the system must be able to withstand very high winds (>200 Km/hr) while also considering temperature extremes.

- Lightning: The Carter 300 wind turbine structure is grounded by the presence of wires in the blades.

The following is Acres Internationals report on icing considerations:

Wind Energy Demonstration Project, Bell Island;

Icing Considerations

Introduction

The accumulation of ice on the wind turbine and support structure may be of concern in two ways

- the effect on the system components of extra loads
- and the possible effect of falling ice on nearby structures.

Ice could accumulate on the wind turbine from atmospheric icing. In order to gain an appreciation of the magnitude of the potential accumulation of ice on the system components, in-house and library references were reviewed, and estimates were made of the weight of ice that might accumulate for different return periods. Calculations of the trajectory of ice pieces propelled from the turbine were also carried out.

Types of Atmospheric Icing

Icing from atmospheric sources can result from contact with supercooled cloud or fog droplets, from freezing precipitation (rain or drizzle) or from wet snow. Each of these types of icing is associated with particular meteorological conditions and results in characteristic types and accumulations of ice.

Cloud and Fog Droplets (1-20 mm in diameter) can exist in a liquid state at temperatures well below freezing. When these droplets come into contact with an object, they freeze on impact, forming rime ice. Due to the low water content of the air, this type of icing generally does not pose a problem except for fast moving objects (such as aircraft) or when it occurs in association with high winds. In these cases large amounts of water droplets are brought into contact with the object and ice build up can be considerable.

Freezing Precipitation results when liquid precipitation falling from warm air aloft is cooled below the freezing point as it falls through a layer of cold air nearer the surface. Freezing precipitation can be in the form of freezing rain or freezing drizzle. Freezing rain is defined as having drops more than 0.5 mm in diameter and rates that range from less than 2.5 mm per hour (slight rain) to greater than 7.6 mm per hour (heavy rain). Freezing drizzle is defined as fairly uniform precipitation composed exclusively of fine drops of water of diameter less than 0.5 mm. The rate of fall of freezing drizzle ranges from less than 0.3 mm per hour (slight drizzle) to greater than 0.8 mm per hour (heavy drizzle). Thus accumulations of ice from freezing rain would be greater than from freezing drizzle.

Wet Snow that is blown against an object may stick and change to ice. Cases have been reported of snow forming rime ice 15 cm thick with a density of approximately 0.23 (McKay and Thompson, 1969). Generally these cases are reported when air temperatures are at or near freezing.

The experience with communication towers in Newfoundland has been that the largest loads are due to freezing precipitation (glaze ice) rather than rime ice or wet snow (Weather Engineering Corporation of Canada Limited, 1984).

Frequency and Accumulations of Atmospheric Icing

The frequency of atmospheric icing for Bell Island may be approximated by using records from the St. John's Meteorological Station (Principal Station Data, St. John's Torbay A, 1983). The frequency of occurrence is reported as a percentage of the number of hourly observations.

For the period of record of 1953 - 1982, the percent of observations reporting freezing precipitation was as follows for the period from November through May.

N	D	J	F	M	A	M
0.2	1.9	3.7	5.1	4.7	4.3	0.6

Thus the greatest probability of occurrence of freezing precipitation is in February; however, these data do not give any indication of the relative severity of the accumulation from one month to the next.

Estimates of ice accumulation due to freezing precipitation have, however, been made for St. John's by Chaine and Skeates (1974). Their analysis included an extreme value analysis of ice accumulations on various surfaces. The results for 10, 20, 30 and 40 year return periods are listed in Table B1. The values for a horizontal surface are similar to those used by Newfoundland and Labrador Hydro in the St. John's area (Weather Engineering Corporation, 1984).

Table B1 Computed Values of Ice Accumulation (cm) On Various Surfaces for St. John's (Chaine and Skeates, 1974)

Return Period (Years)	Horizontal Surface	Vertical Surface	25 mm Radial Conductor
10	3.6	4.7	2.3
20	4.3	5.4	2.6
30	4.8	5.8	2.8
40	5.1	6.1	3.0

Possible Ice Loads on the Wind Turbine System

It is possible that significant accumulations of ice will occur on all components of the wind turbine system on Bell Island. The dimensions provided in the manufacturer's brochure and by Newfoundland Light and Power were used in determining the possible weights of ice on the tower, turbine housing, blades and guy wires. It is assumed for all but the guy wires that ice will build up on the windward side of the component only.

The resulting calculated weights of ice on these components are listed in Table B2 for 10 and 40 year return periods. The density of the ice is assumed to be 900 kg/m^3.

Radius of Influence of Falling Ice

Ice falling from the wind turbine could damage equipment or structures located within the falling area. It is understood that the structure housing the control panel for the unit has been protected with timbers, and there is nothing else within the fenced enclosure that could be susceptible to ice damage.

Normally, where practicable, structures are located some distance away from a tower and beyond the radius of influence of falling ice. A rule for this distance has been developed over the years. It is normally taken to be equal to 20 percent of the tower height for 95 percent of the ice, or 15 m (50 ft.) whichever is greater. In the case of the turbine on Bell Island with a tower height of 50 m, this distance would be 15 m since 20 percent of the tower height is 10 m, only. The existing fence is at a distance of 5 m from the tower at its closest point.

For the unlikely case of ice being propelled from the blades of the turbine, (unlikely because the unit should be shut down under icing conditions) it is possible that ice could be thrown further than this rule-of-thumb distance. Given that the blades rotate at 67 rpm, it is possible to calculate approximately the trajectory of ice flying off a blade.

For a blade rotational speed of 67 rpm, the tip velocity would be

11.5 m x 67 rpm = 770.5 m/min (12.8 m/s)

The ice will travel the greatest distance if it is propelled upward at an angle of 45* from the blade. The distance travelled along the ground is then 76.9 m (252 ft.), ignoring any wind effects.

If wind effects are considered, the increase in horizontal velocity of a small piece of ice (say, 10 cm x 10 cm x 6 cm thick, corresponding to a 40 year return period

Table B2 Calculated Weights of Ice on System Components

Component	Dimensions (m)	Surface Area (m^2)	10 Year Accumulation (tonnes)	40 Year Accumulation (tonnes)
Blades	23 dia.	10.5 (each)	0.4	0.5
Nacelle	1.2 m x 3 m (overall)	9	0.4	0.5
Tower	50 high 0.8 dia.	125	4.5	6.8
Guy Wires	50 long .032 dia.	5	0.16	0.25

for thickness), would be about 3 m/s in a 20 m/s wind (45 mph). This would lead to an increase in distance travelled of about 24 m for a total distance of 100 m (330 ft.).

APPENDIX D

CanWEA '89 Paper - September 18 - 21, 1989

BELL ISLAND WIND DEMONSTRATION PROJECT

CASE STUDY

Monty Hunter

Mechanical Engineer
Newfoundland Light & Power Co. Limited

1. INTRODUCTION

Newfoundland Light & Power Co. Limited in conjunction with the Federal Department of Energy, Mines and Resources have installed a 300 kw wind turbine on Bell Island, Newfoundland. This project was undertaken under the Enerdemo Canada Program which was enacted to demonstrate technologies related to renewable and non-conventional sources of energy. The objectives of this project are;

(i) to identify the potential for grid connected wind turbines in Newfoundland.

(ii) to monitor the operational parameters associated with the equipment and assess its performance in the Newfoundland climate.

(iii) to evaluate the project economics based on actual power generated by the wind turbine and the actual capital and operating costs of it.

(iv) to evaluate the reliability of wind generation.

(v) to assess the environmental impact of a wind turbine installation.

(vi) to provide information and technology transfer to interested parties.

2. PROJECT BACKGROUND

This project originated in 1986 when Newfoundland Light & Power Co. Limited made a proposal under the Solar Energy Development Program. This proposal was to determine whether wind turbines could be economically feasible if installed near existing hydroelectric generating sites owned by the Company. This submission was rejected due to the amount of funding required, but the Company was encouraged to pursue the idea with Energy, Mines and Resources.

Over the next two years studies were performed into the feasibility of establishing a wind demonstration project in Newfoundland. The studies included the selection of an appropriate site, the selection of the most cost effective wind turbine, and the determination of the funding required to make the installation a reality.

Sites for the demonstration were selected using the following criteria;

(i) The site must be close to the Company's Head Office in St. John's to permit effective monitoring and maintenance.

(ii) The site topography must be conducive to favourable wind conditions.

Thirteen potential sites were identified from maps and site visits. A matrix method was used to select the optimum location. Parameters which were used in the matrix were;

- acceptable wind conditions
- site topography
- site safety
- possibility of icing
- availability of foundation material
- site accessibility
- possibility for communication interference
- land availability
- demonstration visibility
- connection distance to transmission lines
- possibility for expansion
- site security

Based on this analysis, the Bell Island site was chosen.

The type of wind turbine to be installed was determined by issuing a questionnairre to turbine manufacturers to assess the interest in the project and to obtain information on the production and operating characteristics of the different machines.

Following the review of the responses, tenders were prepared and issued for the supply, erection and commissioning of one wind turbine. The unit sizes were to be between 250 and 500 kW. Bids were received from four companies; Indal Technologies, Carter Wind Systems, Wincon, and Howden. The bids were evaluated with respect to cost and generation. It was determined that the most economical unit was the Carter 300 kW machine. It is estimated that it will produce 650,000 kWhrs annually in an average windspeed of 6.8 M/S. The purchase price of this machine was $330,000.00.

Once the wind turbine was selected a further analysis was done to estimate total project costs. From this, Newfoundland Light & Power's contribution and the requirements from Energy, Mines and Resources were determined. The contribution of the Company was calculated by comparing the present worth of the average annual generation to the present worth of the cost to purchase, erect, test and operate the unit. Parameters used in this analysis were a turbine life of 20 years, an inflation rate of 5%, an annual operating cost of 2% of the machine's price, and a cost of capital of 12.34%.

The project was estimated to cost a total of $596,500.00. Energy, Mines, and Resources agreed to fund 63% of the cost up to a maximum of $343,000.00, 50% of the environmental assessment up to $12,500.00, 100% of the technology transfer cost up to a maximum of $30,000.00, and 100% of the 2 year monitoring cost up to a maximum of $50,000.00.

All of this work culminated in the signing in March of 1988 of the Enerdemo agreement between the two parties. Work was started on the installation immediately with the ordering of the Carter wind turbine on March 31, 1988.

3. UNIT DESCRIPTION

The Carter Model 300 wind turbine is a downwind, two bladed, horizontal axis machine. The 23.5 m diameter blades are fixed pitch, and drive a planetary gearbox connected to an AC induction generator. All components are mounted in a pod on top of a 50 m tilt up tower. Power and control cables are run down from the pod inside the tower. The unit controls are located at the base of the tower in a separate cabinet.

In winds below 3.6 M/S, the blades of the turbine spin freely at a speed proportional to the windspeed. At about 3.6 M/S there is enough energy to bring the blades up to synchronous speed. Once the generator has reached approximately 1800 rpm (blades 67 rpm) the controller signals the silicon controlled rectifiers (SCR's) to fire and tie the unit into the grid. The SCR's can turn the generator on and off 120 times a second and varies the generator excitation voltage. This enables the generator to run at the most efficient voltage for a given load. At loads greater than 100 kw, the excitation voltage is not varied. Even though the generator's excitation voltage is varied, the output to the grid remains constant at nominally 600V.

At the on line point, the generator produces under 1 kw of power and at approximately 16 M/S 300 kW is produced. Momentary peaks of up to 330 kW occasionally occur in high, gusty winds. As the windspeed exceeds the rated power of the unit, the aerodynamic design of the blades cause stalling to occur which effectively limits the peak power output. No high wind shutdown is required though the controller may be programmed to deactivate the machine at 27 M/S to reduce wear.

Abnormal conditions such as power outages are handled by a safety feature built into the blades. As the blades rotate, centrifugal forces try to force the blade to pitch or twist out of the wind. The blades are kept in place by strong electromagnets inside them. Any loss of voltage removes the power from the magnets and allows the blades to pitch to a high angle of stall. The unit speed reduces to zero and a service brake locks the rotor. The blades gradually reset to the fixed pitch position and the turbine will restart when power is restored.

The pod and blades track the wind using a yaw drive system in low and medium winds. At high windspeeds the yaw drive is disengaged as the blades will naturally track the wind.

As the base of the tower is hinged, the entire blade/pod system may be serviced by lowering it to the ground via a ginpole and winch.

4. INSTALLATION

The installation requirements for this unit were minimal. An access road was built and the site cleared and graded. Foundations were poured for the tower base, control cabinet, and four guy anchors. A small building was erected to house spare parts and communication equipment. The area around the wind turbine was fenced. A 12.5 kV, three phase transmission line had to be run 1.5 km to the site and three transformers were installed to match the unit voltage to that of the transmission line.

The wind turbine arrived on site in mid November and was installed in two days by two workers from Carter and four Company employees. It is interesting to note that the only lifting device required was a small Pittman crane. The transmission line was completed in early December and the unit commissioning began by mid month. Due to some faulty components, the commissioning was not completed until early January after which the wind turbine was placed into operation for a trial "shake-down" period. By mid March the machine was fully commissioned and it was placed in operation for the monitoring phase on April 1, 1989.

5. OPERATING EXPERIENCE

During the months of January, February, and March, 1989, many hours were spent eliminating problems associated with the startup of new equipment. Some of these problems were due to control components rated for 480 volts being used at 600 volts. This was a supplier problem as the unit was specified for use at 600 volts. A fault occurred in the electrical cable between the unit and the transformers. This necessitated the running of temporary cabling above ground until weather conditions permitted replacement. The center phase transformer developed a fault in March which caused damage to the wind turbine's surge protection and main circuit breaker. After installing another transformer and repairing the damage to the unit, a new ground fault protection scheme was installed. After approximately one week into the monitoring phase, cracks were found at the base of the tower. These were caused by maladjustment of a small kickstand at the base of the tower and on raising the tower high stresses were imposed on the failed area. These cracks were ground out and welded and the kickstand placed in the retracted position.

On May 8, a complete maintenance check was performed. At this time 86,181 kWhrs had been produced in 688 available hours. During this inspection, it was discovered that both blades were severely damaged. This necessitated the immediate deactivation of the unit and, as a safety precaution, removal of the blades. The cause of the failure was determined to be due to a manufacturer's design error. In order to minimize the bending of the blade, thrust and centrifugal forces are balanced by angling the blade mounting plates on the hub. This angle was set at 4 degrees which was insufficient thus resulting in excessive bending and eventual failure of the structural members of the blades. Redesigned stronger blades, a blade hub with an angle of 10 degrees and other associated components were ordered from the supplier and were manufactured during the summer. These components were installed during the week of August 21 and the machine put back in service. To date the unit has operated with a minimum of problems.

6. FUTURE WORK

With the Carter wind turbine back into service the monitoring phase will be reactivated. As part of this process it is planned to issue tenders for an environmental evaulation of the installation. The evaluation will address several aspects of the project including;

- acceptance of the general population.
- noise levels.
- effects on wildlife and domestic animals.
- communication interference.
- effect on tourism and visitors to the island.
- safety of surrounding properties and individuals.
- potential health hazards.
- economic benefits/drawbacks.